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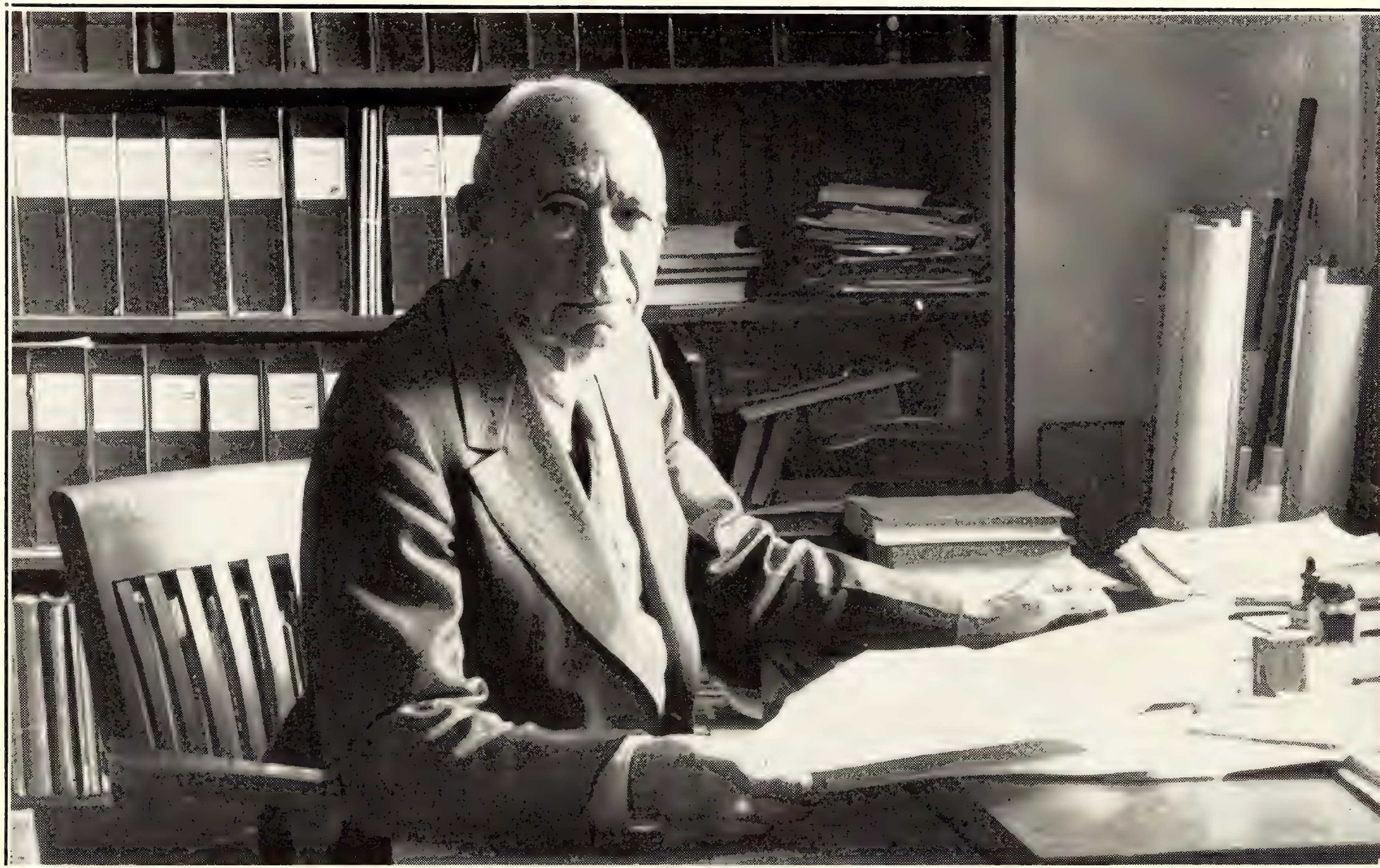

Francis Ramaley (see p. 260)

Frontispiece to Volume 6, Madroño.

CONTENTS

SOME DETAILS OF THE REPRODUCTIVE STRUCTURES OF SARCODES

Bernice E. Doyel and L. Marguerite Goss

The genus *Sarcodes* includes but one species, *S. sanguinea* Torr., the snow flower, a fleshy, saprophytic plant common in the Sierra Nevada in California. This familiar plant has been described in detail by Oliver (6).

Each plant consists of a tuft of roots and a stout erect stem which bears spirally arranged scales. The abundant flowers are borne in the axils of the upper scales; the lower part of the stem may be regarded as a peduncle, and the upper as the rachis of a raceme. The stem, scales, pedicels and sepals are densely covered with multicellular glands. All parts above ground are brilliant crimson.

The flowers are ordinarily pentamerous. The sepals are separate; the petals are united for about half of their length and are entirely glabrous. The corolla and calyx are about equal in length; the tips of the petals curve outward while those of the sepals are slightly incurved. The stamens are ten in number, hypogynous, considerably shorter than the petals and slightly shorter than the pistil. The anther is about half the length of the entire stamen. The filament is ribbon-like, entirely glabrous, and attached to the outside of the anther a little below the middle. Dehiscence takes place by a pair of pores on the outer surface of the anther near the summit. The pistil is glabrous. The oblate-spheroidal ovary is marked by ten grooves in the planes of the filaments; at the base it bears a nectary with ten blunt lobes located between the grooves and projecting between the bases of the filaments. The internal cavity of the ovary is divided by five radiating septa located in the planes of the sepals and bearing massive placentae; in the lower part of the ovary the inner ends of the placentae are fused together so that the placentation is axile, while in the upper part they fail to meet and the placentation is parietal. The placentae bear a very large number of ovules. The cylindrical style, about as long as the ovary, is traversed by an open channel into which ridges, being upward continuations of the septa, project. The capitate stigma is five-lobed; the lobes are placed alternately with ridges which project into the style-channel: that is, they are the ends of the carpels.

We are able to amend or extend Oliver's description by observations of the vascular system of the receptacle, the structure and development of the stamen and the embryogeny. The observations are based on material supplied by Dr. Herbert F. Copeland, to whom we are most sincerely grateful. The material was collected at Jonesville, Butte County, at an altitude of 5000 feet, and fixed in Bouin's fluid. In making slides the usual microtechnical methods were employed and safranin and light green were used exclusively as the stains.

Madroño, Vol. 6, pp. 1–32. January 17, 1941.

Vascular Anatomy

The vascular tissue of the stalk—the peduncle and the rachis of the inflorescence—is to be interpreted as a cylinder, in which, however, the xylem is broken up into separate strands (Pl. 1, fig. 1). There is no sheath of fibers outside the phloem.[1] The departure of each leaf trace leaves one gap in the cylinder; the leaf trace is apparently to be interpreted as a single bundle but early in its course it frequently divides into two and before it enters the leaf breaks up into many. The vascular supply to each flower originates as two bundles, springing from the sides of the leaf-gaps just above the departure of the leaf trace; the two bundles unite in the cortex to form a cylinder, which enters the pedicel. In traversing the pedicel it breaks up into a ring of some five or six bundles.

As the bundles enter the receptacle (Pl. 1, fig. 2), a series of six whorls is given off in acropetal sequence: (1) a whorl of five sepal bundles; (2) a whorl of five bundles alternating with the sepal bundles, each of which splits tangentially into (a) several outer bundles that enter the corolla and (b) one inner bundle supplying an antipetalous stamen; (3) a whorl of five antisepalous stamen bundles; (4) a whorl of many carpel lateral bundles, arising on the inner sides of the bases of all the stamen bundles, and ascending the ovary wall; (5) a whorl of carpel dorsals ascending the ovary wall in the planes of the petal bundles; (6) a whorl of placental bundles in the planes of the sepal bundles. All the bundles in the ovary wall fade out just before reaching the style. The placental bundles enter the ovary in the planes of the septa and continue into and up the style. They fade out in the stigma.

The Stamen

In the youngest stamens we have seen, the relative sizes of the parts are about as at maturity; that is, the filament is rather

[1] "My statement [5] that there is a sheath of fibers in *Sarcodes* was based on inadequate observation"—(orally communicated by H. F. Copeland).

Explanation of the Figures. Plate 1.

Plate 1. Sarcodes sanguinea Torr. Fig. 1. Cross section of peduncle, × 4. Fig. 2. Half of a model of the vascular system in the receptacle, seen from the inside, × 16: *ca*, sepal bundles; *co*, petal bundles; *st*, stamen bundles; *cd*, carpel dorsals; *cl*, carpel laterals; *plac*, placental bundles. Fig. 3. Juvenile stamen, × 16. Fig. 4. Diagram of a longitudinal section of a stamen, showing the course of the vascular bundle, × 16. Fig. 5. Cross section through anther, showing pollen chambers at the plane represented by the line *a* in figure 4, × 40. Fig. 6. Mature stamen, showing open pores, × 16. Figs. 7, 8, 9. Cross sections of mature anther, the planes of which are represented respectively by the lines *a, b, c* in figure 6, × 40. Fig. 10. Cross section of anther wall, being an enlargement of the area marked by the dotted square in figure 9, × 320.

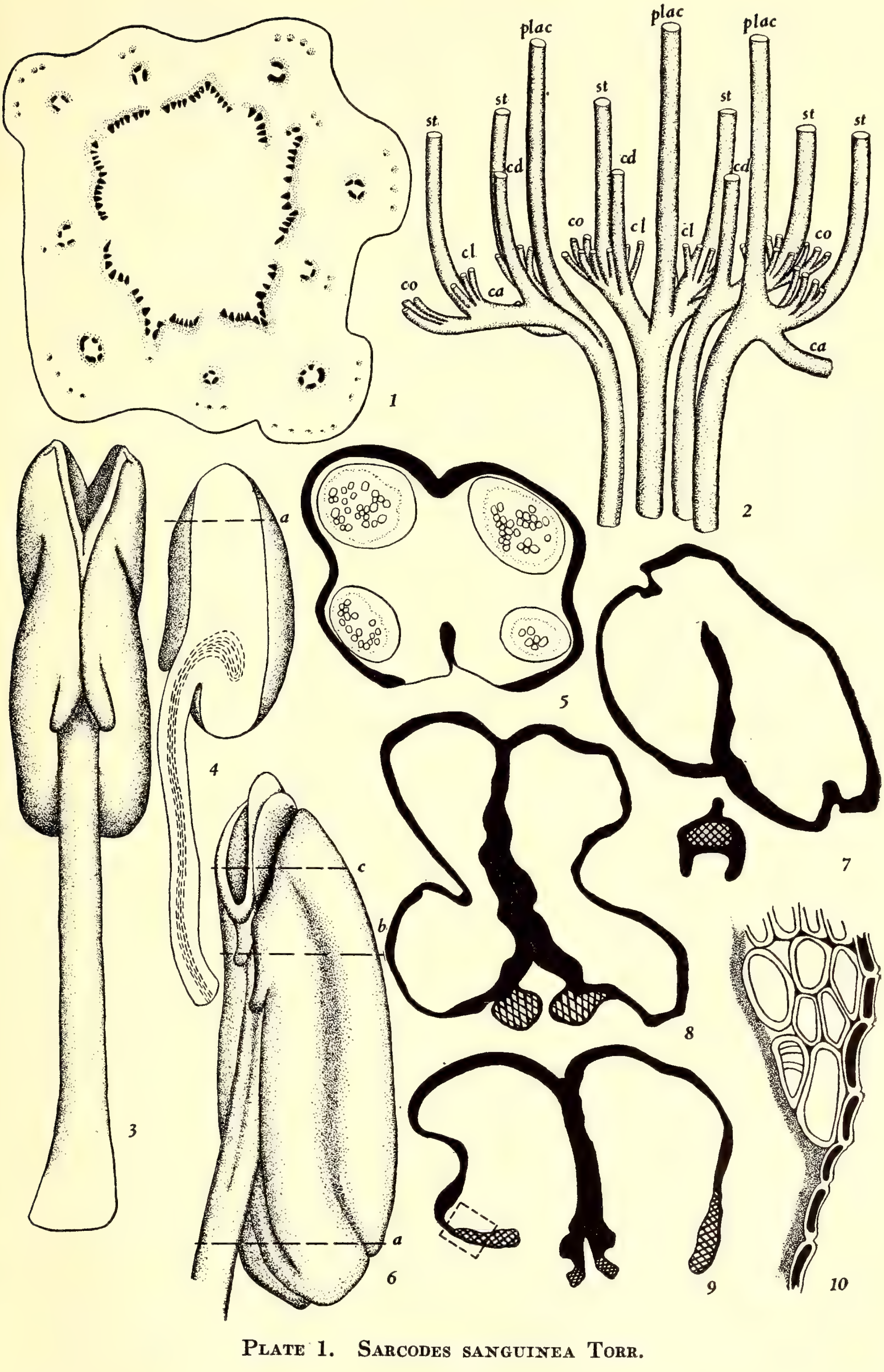

PLATE 1. SARCODES SANGUINEA TORR.

longer than the anther and enters on the outer side below the middle (Pl. 1, fig. 4). The stamen bundle bends so as to run not to the summit of the anther but to the lower end. The anther bears two rudimentary descending horns just above the insertion of the filament on the outside and below the pores (Pl. 1, fig. 3). In the young anther the usual four microsporangia with wall and tapetum are present (Pl. 1, fig. 5). The two pollen sacs on the inner side of the stamen extend somewhat nearer to the summit than those on the outside. The cells of the epidermis or exothecium are tanniniferous except for a patch on the outer side of the upper end of each anther lobe extending across the ends of the two microsporangia of the lobe where the pores are to form. In the youngest material we have examined the pollen grains had already formed. Most of them are four-grooved.

As the anther matures the wall between the two microsporangia of each lobe breaks down (Pl. 1, figs. 5, 7, 8); the connective (the wall in the plane of symmetry) also breaks down through a small part of its extent at the base of the anther; for the most part it persists. Where the pores are to form, and below them in the horns, a body of cells within the epidermis becomes differentiated by thick ribbed walls (Pl. 1, fig. 10). Dehiscence appears to be accomplished by a contraction of the exothecium which tears the body of thick walled cells in two by a lengthwise slit; the slit becomes a pore rimmed by thick-walled cells (Pl. 1, figs. 6, 9).

Embryogeny

The ovules have an integument of about four layers of cells. In the young ovule a few cells of the outermost layer show indications of tannin being present. Later, nearly all the cells of this layer are tanniniferous. The embryo sac develops in the manner usual in Sympetalae. The archesporial cell forms a megaspore tetrad. The spore at the chalazal end of the tetrad enlarges (Pl. 2, fig. 11); its nucleus undergoes three successive divisions which result in four nuclei at the chalazal end and four nuclei at the micropylar end. One nucleus from each end moves toward the center of the embryo sac; there these two nuclei unite to form the endosperm mother nucleus. Cell membranes form around the remaining six nuclei. The three resulting cells at the chalazal end are the antipodal cells. The largest of the three at the micropylar end is the egg and the other two are the synergids (Pl. 2, fig. 13). Meanwhile, the nucellus and the other three spores have disappeared. Following fertilization and before the embryo divides, the endosperm goes through a series of divisions. Each nuclear division is followed by cell division and the first two divisions produce a row of four cells (Pl. 2, figs. 14, 15). The second and third cells of this row (counting from the micropylar end)

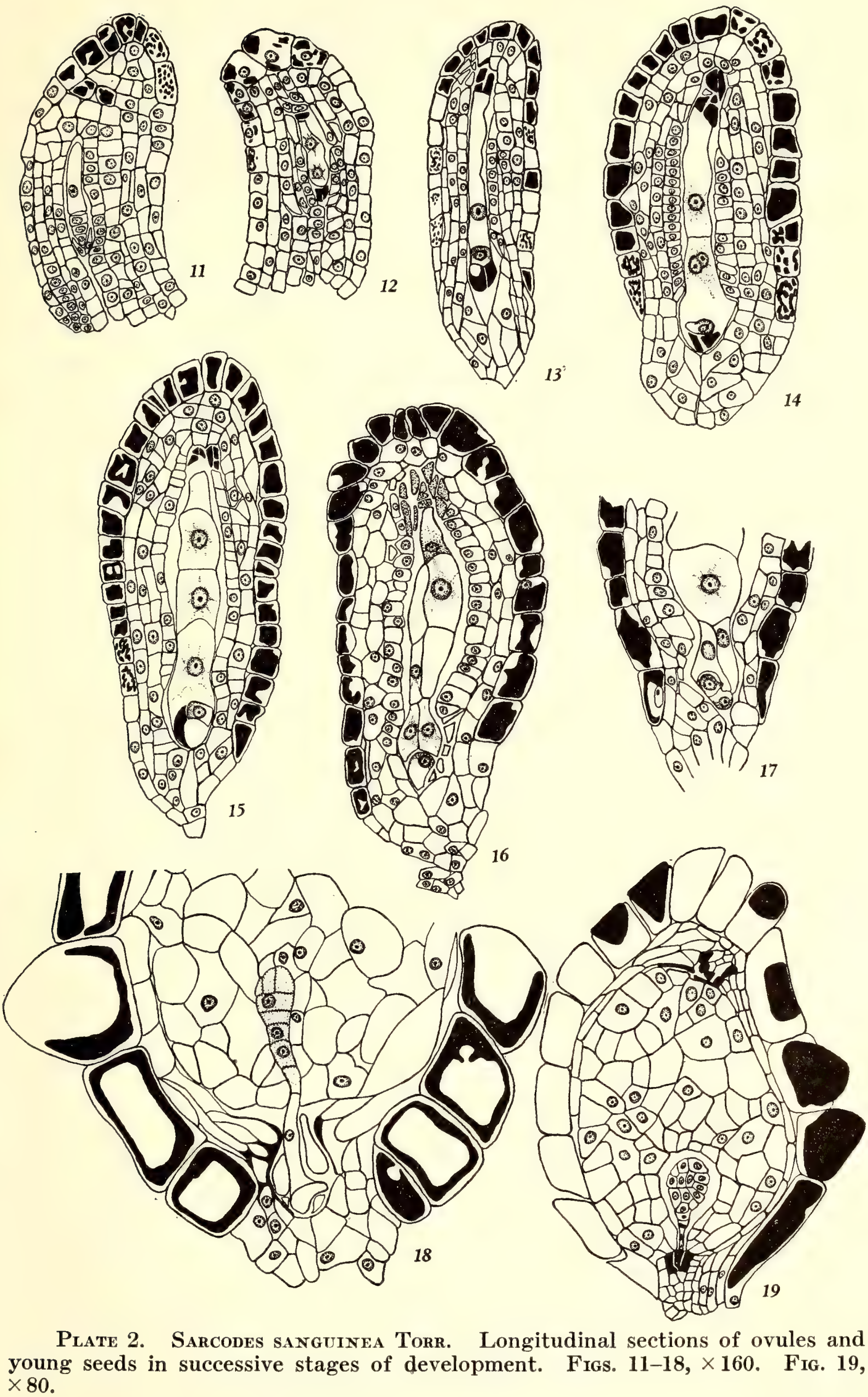

PLATE 2. SARCODES SANGUINEA TORR. Longitudinal sections of ovules and young seeds in successive stages of development. FIGS. 11–18, $\times 160$. FIG. 19, $\times 80$.

divide repeatedly and produce many cells while the first and fourth cells develop into haustoria (Pl. 2, figs. 16–19). At the same time the antipodal cells and the synergids disappear. The zygote first divides into two cells after the endosperm is past the four-celled stage (Pl. 2, fig. 17); of the two daughter cells of the zygote, the one toward the micropyle elongates and forms a suspensor. The suspensor carries its sister cell up to about the level of the wall between the first and second cells of the four celled endosperm. The original suspensor cell undergoes no divisions and grows no farther; its sister cell, by a series of divisions, adds to the suspensor, so that the summit of the embryo is carried in among the cells derived from the second cell of the four-celled endosperm. In this region a globular mass of cells, the definitive embryo, is developed (Pl. 2, fig. 19). By this time the integument has for the most part been absorbed, except for the outer layer of cells which have become thick-walled; the seed is essentially mature.

Discussion

Copeland (1, 2, 3, 4, 5) has made several contributions to the knowledge of the details of the reproductive structures of Monotropoideae. Our studies show that the details of the reproductive structures of *Sarcodes* are essentially in agreement with what he has found. The outer whorl of stamen bundles and the carpel-dorsals are in the planes of the petal bundles. The placental bundles are in the planes of the sepals. The embryo sac is normally developed and of normal type. In certain minor details of the development of the embryo, in which, according to Oliver's figures, *Sarcodes* is different from other Monotropoideae, we were unable to corroborate his findings; apparently *Sarcodes* agrees perfectly with other members of the group.

The integument of most Monotropoideae is of just two layers of cells and the endosperm is of but few cells. The four-layered integument and the mature endosperm of many cells in *Sarcodes* are distinctive characters of the genus.

The course of the bundle in the anther, running as it does to the base and not to the summit, shows that the end of the anther which is toward the base of the flower is the distal end and the end toward the summit of the flower is the proximal end. The stamen develops, in fact, with the distal end of the filament turned in and down, so that the outer, apparently dorsal, surface of the anther is in reality the ventral surface. This structure of the stamen seems to be typical of the order Ericales. The horns, found in many Ericales on the ventral surface of the anthers, are absent in most Monotropoideae, though conspicuously present in *Pterospora*. We think it significant that rudimentary horns, previously unreported, are present in *Sarcodes*.

The four-grooved pollen grains of *Sarcodes* are like those of

Pterospora and *Pleuricospora*. The pollen grains of *Allotropa* are three-grooved, while those of *Monotropsis* have two grooves.

Copeland (5) expressed the opinion that *Sarcodes* together with *Pterospora* and *Allotropa* make up the most primitive tribe of Monotropoideae, being the link between the Ericaceae proper and other Monotropoideae. The characters of *Sarcodes* as we have come to know them lead us to believe that this is the true conception of the line of evolution.

Sacramento Junior College
Sacramento, California, January, 1940

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A STUDY OF ISOETES IN SAN DIEGO COUNTY, CALIFORNIA

Louis C. Erickson

Three species of *Isoetes* occur in San Diego County, California: *I. Nuttallii* A. Br., *I. Orcuttii* Eaton, and *I. Howellii* Engelm. To these species, eleven names or combinations of names have been applied at various times and the validity of at least one of them, *I. Orcuttii,* has been questioned by Norma E. Pfeiffer, the most recent student of the genus. (Monograph of the Isoetaceae. Ann. Mo. Bot. Gard. 9: 79–232. 1922.) In the present study ecological and morphological aspects of the genus are emphasized. The writer is indebted to Dr. A. W. Haupt and to Dr. Carl Epling, both of the University of California, Los Angeles, for suggestions.

The living material studied came from the Kearney Mesa which is about fifteen miles north of the city of San Diego and five to ten miles inland, and from a pool about eight miles farther north. This area is a table-land drained by a system of small streams which have running water only after rains. These streams retain occasional pools along their courses, eventually drying up completely during the long rainless period lasting from May until November or December. Between streams are low mounds covered with a chaparral vegetation, alternating with shallow depressions which retain water throughout the rainy season and in which many small hydrophytes flourish. A more detailed account of this region may be found in a recent article by

Edith A. Purer (Ecological study of vernal pools, San Diego County. Ecology 20: 217–229. 1939).

Numerous specimens from fourteen localities within the area described were collected at different times of the year. Preserved material, collected in the same region some years previously by Dr. A. W. Haupt and Dr. O. A. Plunkett, was also examined. In addition, types and representative specimens of the following were studied: *Isoetes Suksdorfii* Baker, *I. Nuttallii* A. Br., *I. Orcuttii* Eaton, *I. Howellii* Engelm., *I. nuda* Engelm., *I. melanopoda* var. *californica* Eaton; also representative specimens of *I. Underwoodii* Henderson, the type of which has been destroyed by fire. The following descriptions have been based on the material collected near San Diego.

Key to Species

Corm 3-lobed; velum complete
- Peripheral strands in leaves 3; megaspores frosted and predominantly tuberculate .... 1. *I. Nuttallii*
- Peripheral strands in leaves lacking; megaspores usually glossy and predominantly smooth .... 2. *I. Orcuttii*

Corm 2-lobed; velum one-third complete .... 3. *I. Howellii*

1. Isoetes Nuttallii A. Br. ex Engelm., Am. Nat. 8: 215. 1874; Pfeiffer, Ann. Mo. Bot. Gard. 9: 130. 1922. *I. opaca* Nutt. ex. Engelm., St. Louis Acad. Sci. 4: 388. 1882. *I. Suksdorfii* Baker, Handbook of the Fern Allies 132. 1887. *Calamaria Nuttallii* Kuntze, Rev. Gen. Pl. 2: 828. 1891. *C. Suksdorfii* Kuntze, *l. c.*

Corm 3-lobed; leaves 5–75, mean 21, length 2.5–20 cm., mean 8 cm., spreading, usually with a characteristic twist, stomata numerous, peripheral strands 3, subterranean part of mature leaves occasionally with some brown pigment, velum complete, membranaceous margin up to 5 cm. in length, tapering gradually; megaspores gray (or sometimes white, gray, and dark brown to black within one sporangium), dark brown to black when wet, 260–560 μ, mean 380 μ, the markings variable, from distinctly tuberculate to etuberculate on a frosted or occasionally glazed surface; microspores 25–31 μ, mean 27.5 μ, tuberculate.

Isoetes Nuttallii occupies seepage areas along small streams like those found on Kearney Mesa. In contrast with the other two species, *I. Nuttallii* does not grow where water stands, although the plants may be partially submerged after rains. It was noted in several instances that plants growing in the wetter places were being destroyed by worms and bacteria. The soil in which the plants grow varies from a coarse sand containing a small amount of clay to a clay without sand. Many of the plants are shaded by the chaparral shrubs bordering the streams.

Variation may be observed in (a) number and length of leaves, (b) color, size and marking of megaspores and (c) depth of the

corms in the soil. The number of leaves per plant varies from 5 to 75; their length from 2.5 to 20 centimeters. The plants which have the largest number of leaves are not always the plants with the longest leaves. Most megaspores are gray, but within some sporangia three colors may be found: white, gray, and dark brown to black. When plotted according to size, the megaspores of some individuals produce a bimodal curve. Others have megaspores which, when plotted, produce unimodal curves with small dispersion. Between these extremes are all intermediate conditions, some producing skewed unimodal curves, and some producing less pronounced bimodal curves. The marking on megaspores is variable. Ordinarily they are densely covered with tubercles against a frosted surface. In most sporangia, however, some megaspores usually occur on which the tubercles are wholly or partly suppressed; it is the usual condition for the commissural faces of megaspores to be more prominently marked than the free surfaces. The corms may be covered to a depth of 3 to 4 centimeters or, on the other hand, may be so shallow that the sporangia are visible; all intermediate conditions may be found.

The existence of long-leaved and short-leaved plants, three colors of megaspores in a single sporangia and megaspores which produce bimodal curves when plotted for size may be regarded as evidence of gene mutations.

2. Isoetes Orcuttii Eaton, Fern Bull. 8: 13. 1900; Pfeiffer, Ann. Mo. Bot. Gard. 9: 132. 1922. *I. Nuttallii* var. *Orcuttii* Clute, Fern Allies 253. 1905.

Corm 3-lobed; leaves 3–25, mean 8, length 3–6.5 cm., mean 4 cm., spreading, stomata numerous, peripheral strands none, pigment absent from subterranean portions of mature leaves, velum complete, membranaceous margin 1 cm. or less long, narrow; megaspores gray, dark brown when wet, 220–400 μ, mean 320 μ, smooth and glossy, or rarely frosted, sometimes remotely tuberculate; microspores 23–30 μ, mean 26.5 μ, tuberculate.

Isoetes Orcuttii occupies vernal pools only and is submerged during most of the growing season. After the water evaporates from these pools the plants mature in desiccating soil. In all instances *I. Orcuttii* was found growing in clay soil which is soft when wet and extremely hard when dry.

In contrast to *Isoetes Nuttallii, I. Orcuttii* presents very little variation. The leaves exhibit a considerable range in number (3–25) and in this species the larger leaf numbers are associated with the longer leaves. In leaf length the variation is slight (3–6.5 cm.) and does not show the bimodal tendency found in *I. Nuttallii.* The megaspores are uniformly gray with a characteristically glossy surface. Some of the spores have small remote tubercles, and rarely, some of them may be frosted instead of glossy. The megaspores of *I. Orcuttii* are much more uniform in

size than those of either of the other two species. The corms may be covered to a depth of one centimeter at most.

Isoetes Orcuttii occupies a different habitat from that of *I. Nuttallii* and differs also in the following morphological characters: the leaves are fewer and smaller and peripheral bundles are absent; megaspores are predominantly glossy and smooth and average approximately 60 μ less in diameter than those of *I. Nuttallii.* It is evident that although *I. Nuttallii* and *I. Orcuttii* are similar morphologically they differ sufficiently to be considered distinct species.

3. Isoetes Howellii Engelm., Trans. St. Louis Acad. Sci. 4: 385. 1882; Pfeiffer, Ann. Mo. Bot. Gard. 9: 139. 1922. *I. nuda* Engelm., *l. c.* *I. Underwoodii* Henderson, Bot. Gaz. 23: 124. 1897. *I. melanopoda* var. *californica* Eaton in Gilbert, Working List of N. Am. Pterid. 27. 1901.

Corm 2-lobed; leaves 4–56, mean 22, length 5–28 cm., mean 17 cm., spreading, stomata numerous, peripheral strands 4–12, subterranean part of mature leaves usually with abundant dark brown pigment, velum one-third complete, membranaceous margin extending as much as 3 cm. above the soil level and narrowing gradually; megaspores white, tan when wet, 230–600 μ, mean 430 μ, usually distinctly marked with a combination of tubercles and distinct and anastomosing crests; microspores 27–39 μ, mean 34 μ, tuberculate and occasionally spinulose.

Isoetes Howellii is much more widely distributed than either *I. Orcuttii* or *I. Nuttallii,* for while each of these species is strictly limited to a particular habitat as described previously, *I. Howellii* may be found in association with either or may frequently occur alone. It occurs in shallow, quickly drying pools, in pools which retain shallow water and muddy soil, in deeper pools, or in stream beds which are often shaded by chaparral plants. The population of each pool or stream is very limited in area. It is very improbable that the individuals which occupy one vernal pool or stream interbreed with those of another pool or stream. The sporangia are borne too far below ground level for the spores to be blown by the wind and there are no indications that water runs from one pool to another.

The extent to which these differences in environment influence the plants is not known. Nevertheless, there are striking differences between populations of *I. Howellii.* These differences are most evident in the number and length of leaves and the size of megaspores. The first two populations which are summarized in Table 1 exist in two pools which are separated by about fifty feet of higher ground. The first of these is a shallow depression in which the water stands for a short time after rains and, with the exception of *Isoetes* and *Pilularia,* is quite free from plants during the presence of the standing water. In the other pool the

Table 1.

Differences between populations of *Isoetes Howellii*

	Habitat	Leaf length	No. leaves	Megaspore size
1	partially submerged; not crowded	8–18, mean 14 cm.	14–46, mean 26.5	280–410, mean 350 μ
2	submerged; crowded	10–25, mean 18 cm.	5–20, mean 11	320–480, mean 400 μ
3	partially submerged; not crowded	5–12, mean 8.5 cm.	10–31, mean 17.5	300–450, mean 380 μ
4	submerged; crowded	7–16, mean 11.5 cm.	4–14, mean 8.5	350–600, mean 450 μ
5	shaded	9–18, mean 13.5 cm.	7–26, mean 17	300–580, mean 430 μ

water covers the plants during most of the growing season, since by seepage of water it is kept filled for a longer period. Here the *Isoetes* plants are crowded and are in association with small species of sedges. The differences between these populations are not wholly unexpected. In the widely spaced plants of the first population which grow in shallow water and mud uninfluenced by other plants the leaves are more numerous and shorter than in plants of the second population in which the individuals are crowded and submerged. The size of the megaspores also varies, being smaller by an average of 50 μ in the plants of the drier more open pool.

Another partially submerged population, Table 1 number 3, which grows several miles from the two just described is made up of individuals about two-thirds the size of the partially submerged plants of the first population. Similarly, another submerged crowded population, number 4, is made up of individuals about two-thirds the size of the submerged plants of the second population, in these the megaspores are decidedly larger by an average of 50 μ.

The plants thus far considered have been confined to pools. The last population to be considered, number 5, occupies a stream bed and is shaded to a large extent by overhanging chaparral shrubs. These plants differ noticeably from the others by their darker green, more slender leaves. In other characters they are intermediate.

The range in variation in the size of megaspores of individual plants may be very great. Measurements of 400 megaspores from one specimen, indicated a range of from 280–550 μ a dispersion exceeding those given by Miss Pfeiffer for both *Isoetes Howellii* and var. *minima* Pfeiffer. In morphological characters there is complete intergradation between the species and the variety.

University of California,
Los Angeles, California,
July 24, 1939.

A NEW FRASERA FROM OREGON

Morton E. Peck and Elmer I. Applegate

Frasera umpquaensis sp. nov. Planta biennalis glaberrima; caulis robustus simplex 6–9 dm. altus; folia omnia verticosa foliis verticis 3–4, vel superioribus oppositis, elliptico-oblongis vel late lanceolato-oblongis 1–2 dm. longis ad petiolum brevissimum indistinctum contractis; inflorescentia interrupta densa 1–3 dm. longa ramis infimis in axillis foliorum superiorum, bracteis parvis pedicellis plerumque brevioribus floribus; lobis calycis linearibus vel lanceolato-linearibus paulum inaequalibus 9–12 mm. longis, quoque ad basin intus cristam setarum brevium ferente; corolla viridescente alba paulo breviore calyce profunde 4-partita cristas setarum longarum inter lobos ferente, lobis ad apicem minute 3–4-dentatis, foviis solitariis magnis profundis suborbiculatis in circitu membrana profunde fimbriata marginatis; filamentis anguste linearibus; capsulis compressis.

Glabrous biennial; stem solitary from a short caudex, stout, simple, 6–9 dm. high; leaves all in whorls of 3 or 4 or the uppermost opposite, elliptic-oblong or broadly lance-oblong, 1–2 dm. long, narrowed to very short, ill-defined petioles; inflorescence 1–3 dm. long, interrupted, dense, the lowest branches in the axils of the upper leaves, the bracts above much reduced, the pedicels a little longer to much shorter than the flowers; calyx-segments linear to lance-linear, somewhat unequal, 9–12 mm. long, each with a tuft of short setae at base within; corolla greenish white or pale yellowish, a little shorter than the calyx, deeply 4-parted, with a tuft of long hairs just below each sinus, the narrowly ovate-oblong divisions 3- or 4-toothed at tip, the nectariferous pit near the base large and deep, suborbicular, extending nearly across the segment and bordered all round by a narrow membrane bearing a fringe of long setae, the area below the pit bearing similar setae; filaments filiform, about half the length of the corolla-divisions; capsules compressed.

Type. Anderson Camp, Umpqua-Rogue Trail on the summit of the divide, northwest corner of Jackson County, Oregon, at about 6000 feet elevation, July 11, 1929, *Applegate 5930* (Dudley Herb., Stanford Univ.). Additional collection: slopes of Abbott Butte, Rogue River National Forest, July 2, 1936, *Thompson 13067*.

This large robust plant has the general aspect of *Frasera speciosa* Dougl. and *F. fastigiata* (Pursh) Heller but is more closely related to the latter, having quite similar foveae on the corolla, but differing in the setae and in the characters of the calyx. The species is probably confined to the Cascade Mountains along the divide between the upper Rogue and Umpqua rivers.

Willamette University,
Salem, Oregon,
March 25, 1940.

NEW PLANTS FROM OREGON

Morton E. Peck

The plants here described have been known to the writer for many years, but he has been hesitant about naming them, hoping that they might be assigned to species already published. This having been found impossible, they are now described as new.

Sophora Leachiana sp. nov. Caulis erectus ad basin simplex 3–5 dm. altus minute canescenti-tomentosus; foliis compluribus supra confertis 1–2 dm. longis, foliolis 19–33 late oblongis utroque rotundatis 1.5–2.5 cm. longis tenuibus villoso-tomentosis, subter pallidioribus supra parce adpresso-pubescentibus; racemo terminali 7–15 cm. longo floribus 10–25 in pedicellibus 2–5 mm. longis; calyce late tubulari-campanulato supra valde gibboso 7–9 mm. longo lobis brevibus late triangularibus; petalis flavis 9–12 mm. longis; fructu maturo inviso, immaturo valde sursum curvato terete, inter semina constricta, ut videtur, stipite 3–4 mm. longo; seminibus paucis.

Stem erect, simple below, 3–5 dm. high, finely grayish-tomentose; leaves several, somewhat crowded above, 1–2 dm. long, the leaflets 19–33, broadly oblong, rounded at both ends, 1.5–2.5 cm. long, thin, villous tomentose and paler beneath, thinly appressed-pubescent above; racemes solitary or few, terminal, 7–15 cm. long, the flowers 10–25, on pedicels 5 mm. long or less; calyx broadly tubular-campanulate, strongly gibbous above, 7–9 mm. long, the teeth short and broadly triangular; petals yellow, 9–12 mm. long; mature fruit not seen, immature, strongly curved upward on a stipe 3–4 mm. long, few-seeded, apparently constricted between the seeds, gray-tomentose.

Type. Rand Ranger station near Galice, Josephine County, Oregon, June 18, 1933, *Mrs. Lilla Leach 4343* (type in private herbarium of Mrs. Leach, Portland, Oregon).

Sterile material of this interesting plant was collected in 1921 by Douglas C. Ingram (*1221*) of the United States Forest Service "on the trail to Pea-vine Mt.", probably within a mile or two of the type locality. Mr. Ingram's material was doubtfully referred to *Amorpha* by government taxonomists. Since then Mrs. Leach has collected flowering and young fruiting material near the same locality on three occasions, thus making possible a correct diagnosis. The plant blooms freely but apparently fruits very sparingly. Mrs. Leach has collected very extensively in southwestern Oregon, and would probably have come across the plant elsewhere were it not of extremely local distribution. I take pleasure in adding this to the list of Oregon plants that bear her name.

Sidalcea maxima sp. nov. Caules erecti dense caespitosi 8–12 dm. alti robusti ad basin saepe 1 cm. crassi, glauci glaberrimi

usque ad inflorescentiam; foliis supra glabris subter sparse et minute puberulis, foliis caulinis compluribus inferioribus et radicalibus 6–10 cm. latis prope ad medium 7–9-fissis, segmentis plerumque leve 3-lobatis, mediis et superioribus 3–5-partitis segmentis lanceolatis vel linearibus 3–10 cm. longis; racemis usque ad 2.5 dm. longis infra glabris supra minute puberulis; floribus sparsis; pedicellis brevissimis minute puberulis, bracteis linearibus integris subtentis; calyce 8–13 mm. alto sparse et minutissime stellato, lobis angustis triangulari-ovatis; petalis clare roseo-purpureis latis apice prope truncato 2–3 cm. longis; carpellis (immaturis) dorso levibus.

Stems in large dense clusters, 8–12 dm. high, robust, often 1 cm. thick at base, freely branched from near the base, glaucous and completely glabrous to the inflorescence; leaves glabrous above and nearly so beneath, with only a few minute stellate hairs, the cauline leaves rather numerous, the basal and lower 6–10 cm. wide, cleft nearly to the middle into 7–9 mostly shallowly 3-lobed divisions, the middle and upper cauline parted into 3–5 mostly entire lanceolate or linear divisions 5–10 cm. long; racemes up to 2.5 dm. long, sparsely flowered even in anthesis, the rachis glabrous below, minutely puberulent above; lower flowers of the raceme on slender glabrous stalks 1–8 mm. long, the very short and finely puberulent pedicel subtended by an entire linear bract apparently near the summit of the pedicel; calyx 3–11 mm. high, thinly and very minutely stellate, the lobes narrowly triangular-ovate; petals bright rose-purple, broad, nearly truncate at apex, 2–3 cm. long; carpels (immature) apparently smooth on the back.

Type. On moist bank along Dairy Creek, twenty miles northwest of Lakeview, Lake County, Oregon, July 3, 1927, *Peck 15435* (Herb. Willamette Univ.).

This tall robust plant is characterized by its almost complete lack of pubescence and its large showy flowers.

Sidalcea spicata (Regel) Greene var. **tonsa** var. nov. Folia subter plerumque sine capillis longis; calyx sine capillis longis patentibus, lobis interdum bracteis adpresso-ciliatis; inflorescentia plerumque patentior pedicellis longioribus.

Leaves rarely with any long hairs beneath; calyx without any long spreading hairs, but the calyx-lobes as well as the bracts often appressed-ciliate; inflorescence usually less dense, often with longer pedicels.

Type. Meadow, Big Summit Prairie, Ochoco National Forest, Oregon, June 30, 1932, *Peck 17224* (Herb. Willamette Univ.).

Typical *Sidalcea spicata* is common in the southern counties of Oregon from Curry County to Lake County, reaching its most characteristic development west of the Cascade Mountains. To the north and east of this area it passes gradually into the variety here described. Though numerous intergrades occur along the

indefinite boundary of the ranges, the differences elsewhere are so strongly marked and consistent that it seems advisable to distinguish the two by name. The variety is plentiful throughout most of Oregon east of the Cascades from northern Klamath and Lake counties northward and eastward.

Willamette University,
Salem, Oregon,
March 25, 1940.

FIELD CHARACTERS DISTINGUISHING PINUS PONDEROSA AND PINUS JEFFREYI

Kenneth E. Bradshaw[1]

Western conifers offer relatively few problems in taxonomic differentiation to the field man, but one frequent source of confusion and controversy lies in the similarity between the common western yellow pine (ponderosa pine), *Pinus ponderosa* Dougl. ex Laws. and its close relative Jeffrey pine, *Pinus Jeffreyi* Grev. and Balf. ex A. Murr. These species may be found occupying separate ecological niches (Jeffrey pine has a higher elevational range and occurs on drier sites than western yellow pine and will replace it on serpentine formations at the lower elevations) or they may be found growing intermixed. While certain typical stands or individual trees may be quite readily identified, others defy identification by the use of a simple key and generalized descriptions of the species in question. The following pages contain a list of comparative external features which should greatly facilitate the separation of the two species in the field. Remarks on segregations based on the internal structural and chemical qualities of the wood and foliage, which are essentially tasks for the laboratory, have not been included. Grateful acknowledgement is made of certain technical assistance given the writer by Mr. Lloyd Austin of the California Forest and Range Experiment Station.

When using these comparisons, it must be remembered that it is seldom adequate to attempt to identify a tree by using one character to the exclusion of the others. Numerous local strains with distinct morphological and physiological differences result in extreme variation. Certain trees have characters of both species, due probably to cases of inter-breeding. At times but one feature, such as characteristic cones beneath an isolated tree, or distinctly brownish inner bark scale surfaces, may be used as a primary distinction which would point to a Jeffrey pine. Certain trees, however, which otherwise resemble western yellow pine have cones similar to those of the Jeffrey pine or the brownish inner bark scale surfaces characteristic of that species. There-

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YOUNG TREES

Pinus ponderosa	*Pinus Jeffreyi*
FOLIAGE: texture relatively fine, yellow-green, glossy; striae of stomata fine, scarcely distinguishable.	FOLIAGE: needles thicker, longer, coarser, blue-green; powdery white because of the prominent striae of stomata which are well defined and readily counted.
LEADER: flaky bark high on slender leader, length of roughened new growth short; dull gray; resin-filled pustules none.	LEADER: flaky bark not extending so high on the somewhat stouter leader, leaving conspicuous long, smooth, silvery gray area; resin-filled pustules numerous.
BUDS: orange or brick red, conic-ovate, acute; scales closely appressed, surface with resinous exudations, generally in form of numerous tiny droplets.	BUDS: darker with purple or chocolate brown tone; somewhat stouter, more elongate, less acute; scales without resinous exudations, tips less closely appressed.
TWIGS: surface of season's growth shinging green, previous years' growth brownish.	TWIGS: surface of season's growth green, glaucous or pruinose; previous years' growth brownish or greenish but retaining the bloom in perceptible density.
BARK: soft, somewhat resinous; ridges wide, not much inter-connected; furrows shallow, flaky with bark scales; varying from blackish to yellow-brown, tawny or dull orange; inner surfaces of bark scales powdery dull to brilliant sulphur-yellow.	BARK: hard, non-resinous; ridges narrow, irregularly connected giving a braided appearance; furrows deep, distinct, not flaky, laminations of bark very distinct on edges; generally dark gray with slight purplish or reddish-brown cast; inner surfaces of bark scales creamy pinkish- or chocolate-brown.

fore a dominance of one group of characters over the other must be the basis for establishing an identification, unless the tree in question represents a typical case of direct hybridization.

The writer has found that certain characters are best used in the identification of young trees, while others are more serviceable in segregating the older trees. With this consideration in mind, there have been set up practical groups of data for each of these two broad age classes. Trees of intermediate age may be identified by the use of either one of the groups or parts or all of both. Variations in the presence and quality of significant factors with age, size, and condition of the individual trees must be taken into account when using the descriptions contained in this paper. In evaluating the characters of special structures the following modifying conditions should be noted:

FOLIAGE. Foliar differences have been found useful only with the smaller pole-size and seedling trees; they are best used when the two species are growing intermixed so that relative comparisons can be made.

TWIGS. Color of the twigs or previous years' growth has been found to be exceptionally constant as a distinguishing feature; it

Old Trees

Pinus ponderosa	*Pinus Jeffreyi*
Foliage: often perceptibly yellowish; relatively sparse, in ball-like tufts at ends of branchlets, needles persisting approximately 3 years.	Foliage: somewhat blue-green, darker; more dense, needles slightly longer and coarser, persisting 5 to 8 years.
Bark: generally tawny, yellow-brown or dull orange; inner surface of scales, especially near ground level powdery dull to brilliant sulphur-yellow, frequently a distinctive and reliable character; interior of scale brown or tan; scales somewhat soft, a small piece usually dislodged when lightly struck with fingernail; small dark resin pits present throughout.	Bark: externally, color similar to that of *P. ponderosa,* or dark reddish brown, or wine color; plates similar to those of *P. ponderosa* or in more typical specimens somewhat narrower with deeper separating grooves; inner surface of scale light creamy pinkish- or chocolate-brown; interior of scale deep reddish; scales more glossy, harder, merely dented when lightly struck with fingernail; resin pits lacking.
Odor: slight, resinous.	Odor: rather strong, pleasant, sweet, described as resembling that of pineapple, mellow apple, vanilla, or violet.
Limbs: stout, often grotesquely gnarled and bent in very old trees; comparatively short, straight and stout in younger mature specimens, sometimes slightly upturned at ends.	Limbs: less stout and angled, often slender, elongate, more distinctly upturned at ends in typical specimens; retained on bole somewhat longer, resulting in a longer, more symmetrical crown.
Cones: somewhat ovate; about 3–6 inches long, the spreading scales appearing slender and widely spaced; prickles short, the points over most of the cone protruding outward from the umbos, often hooklike, evident to the touch.	Cones: elliptical or long-oval, resembling an old-fashioned bee-hive; about 6 to 10 inches long, scales relatively more numerous, stout, closely compacted, projecting almost horizontally from the cone axis, thus appearing heavier and denser; prickles long, mostly deflexed, the points straight or even slightly turned in, seldom protruding outward except sometimes on the upper 4 to 5 whorls of scales, scarcely perceptible to the touch.

is the only reliable means for determining the species of very young seedlings.

Bark. Ridge and furrow characters are rather distinctive but hard to see on very small trees just beginning to form bark, and not so apparent on trees over sixteen inches in diameter at approximately breast height.

Odor. The use of odor in identification is best employed on older trees, but may be found helpful to supplement the appearance of the bark in young trees which are beyond the stage where the leader and foliage color can be relied upon. Certain individuals of *Pinus ponderosa* and *Pinus Jeffreyi* have disturbingly similar odors, and since hybrids become chemically as well as physically intermixed, this feature should not be relied upon solely. Variation in olfactory sensitivity among observers also decreases the value of this method of differentiation.

CONES. Unopened cones of both species are quite as useful for identification as the opened cones. The immature cones of *Pinus ponderosa* are generally green in color, while the cones of *Pinus Jeffreyi* are generally purple, but there are so many variations and reversals of this rule that color should not be considered an identifying feature in all localities. Cone lengths are also variable, departing from the approximations presented here to such an extent that, except for specimens showing extremes of size, they should be considered much less reliable than the other features mentioned.

Soil Conservation Service,
United States Department of Agriculture
Berkeley, California, December, 1939.

A NEW SPECIES OF ASTRAGALUS FROM ARIZONA[1]

C. L. PORTER

Astragalus Beathii sp. nov. Radix perennis; caules plurimi, 4–6 dm. longi, striati seu sulcati, glabri; folia 10–15 cm. longa, foliolis 11–21, plerumque oppositis, nunc ellipticis, obtusis, nunc ovato-obcordatis, basi in petiolulum perbrevem attenuatis; racemi 10 ad 20 flori, floribus densis, purpurascentibus; calyx oblongus, pilis albis, dentibus brevibus lanceolato-subulatis; vexillum ovatum, attenuatum, obtusum, fere 22 mm. longum; carina obtusa; legumen cartilagineum, glabrum, fere 3–4 cm. longum, oblongi-cylindraceum, semibiloculare, polyspermum, sutura superiore obtusa, inferiore introflexa; legumen, sectione transversa, rotundum videatur; semina reniformia, fere 3 mm. longa.

Plants perennial, many stemmed from the summit of a strong taproot, the stems erect, glabrous, striate to sulcate; leaves pinnately 11- to 21-foliolate, 10–15 cm. long, strigose when young, becoming glabrate when mature; leaflets varying from elliptical and obtuse in upper leaves to ovate-obcordate in basal leaves, those of the basal leaves often much smaller, subopposite on the rachis, and narrowed below into a very short petiolule; racemes 10- to 20-flowered, the flowers dense, purple; calyx oblong, white-strigose, the teeth short lance-subulate, about one-third the length of the tube; banner ovate, attenuate at base, obtuse at apex, about 22 mm. long, moderately arched; keel obtuse; legume coriaceous when mature, fleshy when young, sessile or subsessile, glabrous, about 3–4 cm. long, 7 mm. wide and thick, oblong-cylindrical, rounded in cross section, the upper suture obtuse, not prominent, the lower suture intruded and forming a thick septum about 2 mm. high within; seeds numerous, reniform, about 3 mm. long.

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[1] Contribution no. 181 from the Department of Botany and the Rocky Mountain Herbarium of the University of Wyoming, Laramie.

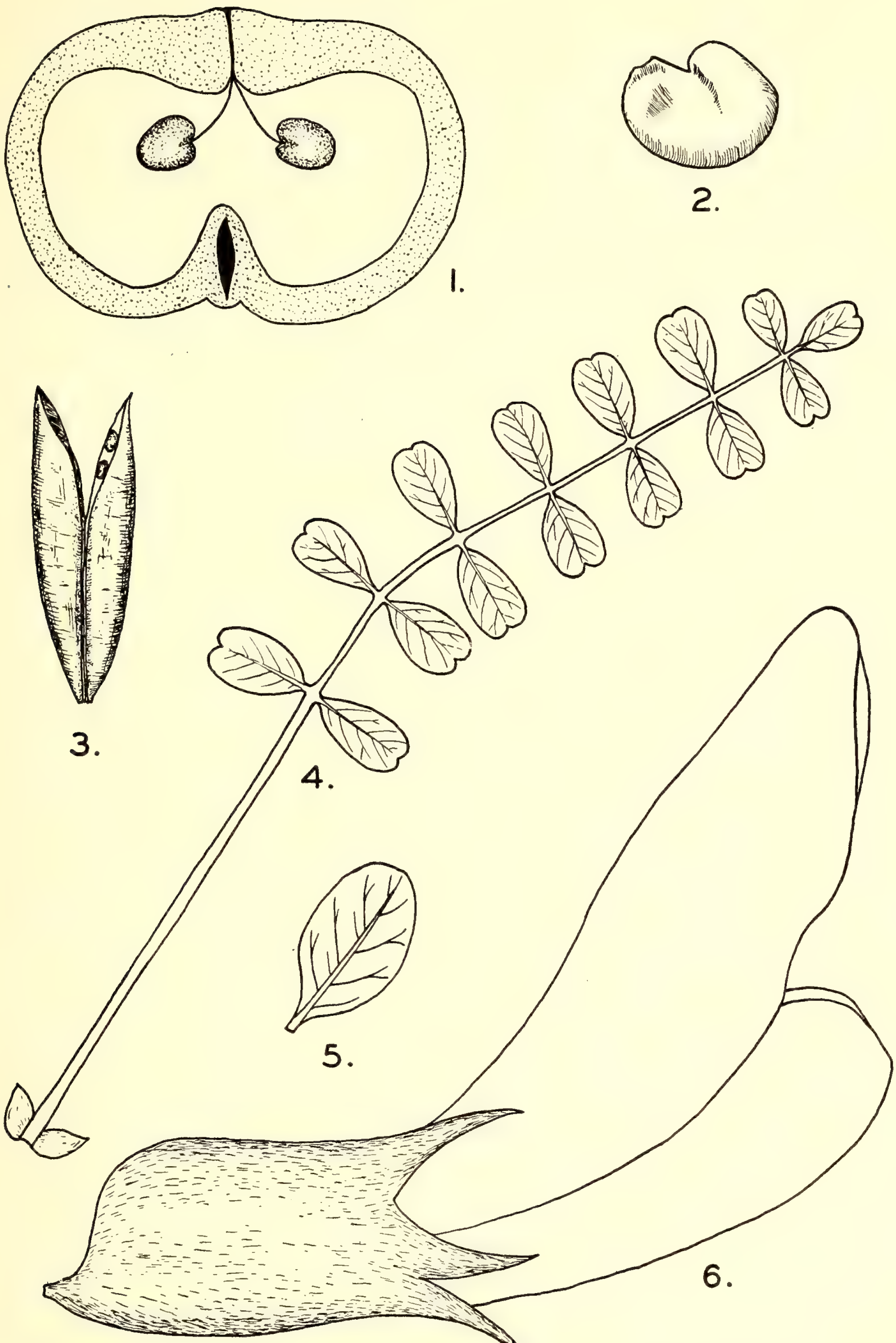

PLATE 3. ASTRAGALUS BEATHII PORTER. FIG. 1, median section of mature pod × 5; fig. 2, seed × 5; fig. 3, mature pod in ventral view × 1; fig. 4, basal leaf × 1; fig. 5, leaflet of cauline leaf × 1; fig. 6, flower × 5.

Type. Two miles south of Cameron, Coconino County, Arizona, June 10, 1939, *L. N. Goodding Sel. 34–39* (Rocky Mountain Herbarium; isotype, Missouri Botanical Garden).

This species may be referred to section Preusii of Jones (Rev. Astrag. 1923) and to the genus *Jonesiella* of Rydberg (N. Am. Fl. 24: 401. 1929). The elongated, straight, cylindrical, sessile or subsessile pods and the dark purple flowers, as well as the erect many-stemmed growth from a strong taproot will readily distinguish it from any of its near relatives. It appears to be very limited in distribution, being found only in the type locality as far as is known, but there it is quite abundant and conspicuous.

The writer takes pleasure in naming this plant for Professor O. A. Beath who first discovered it while on a field trip in connection with his work on seleniferous plants. Since he was unable to obtain mature fruit at the time he first saw it, he informed Mr. L. N. Goodding of the locality and it was through Mr. Goodding that the type material was later obtained.

University of Wyoming,
Laramie, January 24, 1940.

ALBERT RADDIN SWEETSER

(1861–1940)

In the death of Dr. Albert Raddin Sweetser the Pacific Coast has lost one of its best-loved teaching botanists. Dr. Sweetser was born at Mendon, Massachusetts, July 15, 1861, the son of a Methodist minister. His early education was obtained in Massachusetts, in the public schools and at Wilbraham Academy. Entering Wesleyan University, Middletown, Connecticut, in 1880 he received from that institution the degree of Bachelor of Arts in 1884 and of Master of Arts in 1887. Then followed a year at Massachusetts Institute of Technology, where he took special work in chemistry. His first teaching was done in the public schools, Cape Cod, and later at Bucksport, Maine, where he taught in a Methodist seminary. While at Bucksport, in 1888, he was married to Carrie K. Phinney, whom he had met on Cape Cod. His next teaching position was in a Methodist school at Tilton, New Hampshire. In 1893 he entered the Harvard Graduate School of Botany, and remained there for four years. During his last two years at Harvard he was an assistant in botany and at the same time was teaching in Radcliffe College. In 1897 he accepted an invitation to join the faculty of Pacific University at Forest Grove, Oregon. He went to the University of Oregon in 1902 as Professor of Biology, and in 1909 became head of the Department of Botany, a position he occupied until his retirement in 1931. In that year the faculty of the University of Oregon conferred upon him the honorary degree of Doctor of Science.

PLATE 4. ALBERT RADDIN SWEETSER.

He died at Eugene, September 12, 1940, at the age of seventy-nine years.

Dr. Sweetser was co-author with Mary E. Kent of a small popular "Key and Flora" of Oregon, and the author of a number of shorter scientific articles. During the later years of his life he became greatly interested in the botanical history of the Pacific Northwest, and has left a great deal of collected material on this subject, none of which, unfortunately, has been published.

His greatest contribution, however, has been as a teacher, and it was in this field that he himself felt that his most important work lay. His deep understanding of the problems of young people, his kindly personal interest, and his keen sense of humor have endeared him to the many students who have come in contact with him during his years of instructing. It was his purpose to build an appreciation of nature in as many people as possible, and to this end he wrote a considerable number of popular botanical articles for newspapers and journals and accepted frequent invitations to lecture before various clubs. Another of his major interests was the conservation of the native flora and much of his work was directed to that end.

He was a member of Sigma Xi, the American Association for the Advancement of Science, the Medical Society of America, the Society of American Bacteriologists, the Botanical Society of America, the American Association of University Professors, the National Geographic Society, and an associate member of the American Museum of Natural History.—LeRoy E. Detling, University of Oregon, Eugene.

A NEW SPECIES OF PARONYCHIA FROM MEXICO[1]

Earl L. Core

While checking over several sheets of *Paronychia* from various herbaria, the writer came across a specimen from the collection of Dr. Edward Palmer which apparently belongs to an undescribed species. For this plant the following name is proposed:

Paronychia albomarginata sp. nov. Herba perennis, e caudice crasso lignescente; caule ramosissimo a basi incipiente, 4–7 cm. longo, puberulente cum internodis numerosis brevis; foliis linearibus vel linearibus-oblongis, puberulentissimis, 3–4 mm. longis, acutis vel mucronatis a stipulis celatis; stipulis argenteis folia aequantibus vel excedentibus; bracteis brevioribus quam flores vix eis paribus; cymis parvis; calycis segmentis 2 mm. longis, puberulentibus, cum marginibus albis conspicuis, in cuspide breve et erecta terminantibus; staminibus sepalorum longitudine dimidiis.

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[1] Contribution No. 12 from the Herbarium of West Virginia University.

Perennial from a thick woody tap root; stem much branched from the base, 4–7 cm. long, puberulent, with numerous short internodes; leaves linear or linear-oblong, densely puberulent, 3–4 mm. long, acute or cuspidate, hidden among the stipules; stipules silvery, ascending, equaling or exceeding the leaves; bracts shorter than or barely equaling the flowers; cymes small, few-flowered; sepals 2 mm. long, puberulent, with conspicuous white margins, tipped by a short erect cusp; stamens half the length of the sepals.

Type. Saltillo, State of Coahuila, Mexico, April 9, 1905, *Edward J. Palmer 518* (Britton Herbarium, New York Botanical Garden; co-type in Herbarium of Missouri Botanical Garden).

This plant is obviously related to *Paronychia Wilkinsonii* S. Wats., from which species it differs principally in the length of the sepal awns, which in *P. Wilkinsonii* are half the length of the sepals or longer and widely spreading, whereas in the present species they are very short and erect. Other differences are in the leaves, which in *P. Wilkinsonii* are 4–6 mm. long, in *P. albomarginata* only 3–4 mm. long; in the stipules, which in *P. Wilkinsonii* are widely spreading, about equaling the leaves, and in the present species erect, generally exceeding the leaves; and in the size of the flowers, about 3 mm. long in *P. Wilkinsonii,* and only about 2 mm. long in *P. albomarginata.*

West Virginia University,
Morgantown, West Virginia,
March 7, 1940.

GREAT BASIN PLANTS—III. CARYOPHYLLACEAE

Bassett Maguire

The North American pinks have received no serious study[1] since the revision by Robinson in 1897. Progress in the knowledge of our western forms has undergone little advancement since. In attempting to identify new material and to order that of the herbarium more than ordinary difficulty has been encountered, due to this lack of progress and to the multiplicity of forms occurring in recent collections. In his treatment of the family, Robinson (4) constantly referred to the complexity and confusion existing in its taxonomy. Hultén (2, p. 166) has remarked concerning a segregate of *Cerastium Beeringianum,* "Owing to the great variability and lack of distinctive characters the taxonomy of the above-mentioned plants is very confusing." This statement might well apply to the entire family and, in our concern, particularly to the family in our region.

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[1] The first part of the revision of the Western Hemisphere members of *Spergularia* by Dr. R. P. Rossbach appeared in the March, 1940, issue of Rhodora.

In anticipation of further more extended studies, the following preliminary report may now be made.

Cerastium Beeringianum Cham. & Schlecht. var. grandiflorum (Fenzl.) Hultén. From a considerable and diversified population which apparently must come under the above specific name, the variant with petals exceeding 9 mm. (following Hultén) is probably best referred to var. *grandiflorum*. This variety is apparently a new record from our region. These plants possibly represent also *C. pulchellum* Rydb. and *C. Earlei* Rydb.

Arenaria Fendleri Gray subsp. **genuina** nom. nov. *A. Fendleri* Gray, Mem. Am. Acad. n. ser. 4: 13. 1849.

Arenaria Fendleri Gray subsp. **brevifolia** subsp. nov. Caudicibus multicipitalibus, caulibus numerosis, plerumque basibus foliorum vestito, 4–20 cm. altis; foliis 1–3 (6) cm. longis; inflorescentibus 1–3 (5) cm. longis, glandulosis; sepalis anguste lanceolatis, acutis; petalis elliptico-oblongis, obtusis vel retusis, 7–9 mm. longis.

Stems numerous, 4–20 cm. high, from a multicipital caudex borne on a thick root, the stem bases conspicuously clothed with grey-brown remains of previous leaves; leaves 1–3 (6) cm. long; inflorescence open or somewhat congested, 1–3 (5) cm. long, conspicuously glandular-pubescent; sepals narrowly lanceolate, acute, hardly acuminate, the inner more broadly scarious-margined, 5–7 mm. long; petals elliptic-oblong, obtuse or merely retuse, 7–9 mm. long, claws 1–2 mm. long; capsule shorter than the sepals.

Type. Meadow, 11,300 feet, Burro Pass, La Sal Mountains, Grand County, Utah, July 18, 1933, *Bassett Maguire et al. 17972.* Cotypes. La Sal Mountains, *Bassett Maguire et al. 1777, 17973, 17974;* Abajo Mountains, San Juan County, Utah, *Maguire & Redd 1175.* (Type and cotypes are deposited at Utah State College.)

Plants of meadows or open slopes and ridges from 10,000 to 13,000 feet known only from the La Sal and Abajo mountains of Grand and San Juan counties, Utah, and one collection (*Maguire 12254*) from Kaibab National Forest, Coconino County, Arizona.

This population is distinguished from the Rocky Mountain race by its shorter leaves, longer petals, somewhat broader and less attenuate sepals, and shorter inflorescence. At the highest elevations it passes into the variant, described below, with much reduced leaves and stems, distinctly the alpine ecotype of the plant of subalpine, Canadian, and Hudsonian habitats.

Arenaria Fendleri Gray subsp. brevifolia var. **brevicaulis** var. nov. Caulibus plerumque 4–8 cm. longis, foliis 1–2 cm. longis.

Stems mostly 4–8 cm. long; leaves mostly 1–2 cm. long; sepals occasionally only 4 mm. long.

Type. Summit of Pilot Mountain, 12,400 feet, La Sal Moun-

tains, Grand County, Utah, July 11, 1933, *Bassett Maguire et al. 17976.* Cotypes. La Sal Mountains, *Maguire et al. 17977, 17978, 17979, 17980.* (Type and cotypes are deposited at Utah State College.)

This low compact plant is evidently the western correlative of var. *Porteri* Rydb. (of which the isotype, *M. E. Jones 716,* is deposited at this institution) of *Arenaria Fendleri* subsp. *genuina.* It is probable that var. *brevicaulis* represents, at least in part, *Arenaria compacta* of the manuals of "Utah." It would seem improbable that our plant is conspecific with *A. compacta* Cov. of California, although Coville (1, p. 67) compares it with *A. Fendleri,* since var. *brevifolia* is definitely a phase of *A. Fendleri,* whereas this latter species does not occur to the west of the Great Basin.

Arenaria capillaris Poir. subsp. **formosa** (Fischer) comb. nov. *A. formosa* Fischer, in De Candolle, Prodromus 1 : 402. 1824.

This entity, apparently not before recorded from Nevada, represents the typical American form of *A. capillaris.* The polymorphic population of subsp. *formosa* has developed a number of variants, the definition of which is not yet clear. This subspecies is represented by the following collections: San Jacinto, Elko County, Nevada, June 13, 1939, *Maguire 16811, 16812;* Diamond A Ranch, vicinity of Jarbridge, Elko County, Nevada, May 29, 1939, *C. York.*

Arenaria aberrans M. E. Jones. A striking *Arenaria* suggesting *A. capillaris* but with immense urnulate capsules resembling those of *Silene* was collected under pine woodland near the south gate of Grand Canyon National Park (Coconino County, Arizona, June 27, 1935, *Maguire 12236*). These plants are undoubtedly an offshoot of *A. capillaris* but have undergone such extreme divergence as to necessitate recognition as a distinct species. It was not realized that this collection represented the second one made of the recently described *A. aberrans* M. E. Jones (Contrib. West. Bot. 37. 1930) ascribed to "Box Elder Co., Utah." The type (*W. P. Cottam 4159*), however, actually came from Mount Dellanbough, Mohave County, northern Arizona, about eighty miles west of our station.

Arenaria Eastwoodiae Rydb. var. adenophora Kearney & Peebles. This interesting desert ecotype, recently described (1939) from the vicinity of Tuba, Coconino County, Arizona, extends northward, as might have been expected, into southeastern Utah. Collections of this variant from San Juan County, Utah, are represented by the following: June 29–July 1, 1933, *Maguire 2900, 5901, 5902, 5903.*

Silene Petersonii sp. nov. Rhizomate gracile, cum gemmis conspicuis nodis; caulibus solitariis vel laxe multicipitalibus, 5–15

cm. altis, simplicibus, aspere retrorse glanduloso-pubescentibus, plus dense nodis; foliis oblanceolatis, 2–3 cm. longis, 4–6 mm. latis, 1-nerviis, aspere glanduloso-puberulis vel scabris; floribus 3–7, raro 1; calycibus campanulato-cylindricalis vel inflatis, 1.5–2 cm. longis, membranis, conspicue 10-nerviis (nervis purpureis) glanduloso-pubescentibus, lobis oblongo-ovatis, obtusis, 4–6 mm. longis, glanduloso-ciliolatis, corollis conspicuis exsertis, roseis ad roseo-purpureis, petalis 2–3 cm. longis, limbis cuneatis, tenue dentatis vel 4-lobatis, lineari-oblanceolatis; capsulis ovato-oblongis, seminibus 2–2.5 mm. latis, tuberculis marginalibus bullatis.

Tap root deep set, giving rise to several slender, light brown rhizomes, 1–2 mm. in diameter, producing conspicuous nodal buds, the rhizomes horizontally extensive, branching, giving rise to single or several loosely multicipital branches; stems simple, 5–15 cm. high, harshly and retrorsely glandular-pubescent; leaves oblanceolate, 2–3 cm. long, 4–6 mm. broad, broadly or narrowly sessile by means of connate, sheathing hyaline bases, 1-nerved, harshly glandular-puberulent, the upper leaves somewhat reduced; flowers 3–7, or seldom only 1, nodding during anthesis, pedicels 1–2.5 cm. long, seldom only 5 mm. long, calyx campanulate-cylindrical, conspicuously inflated at maturity, 1.5 (1)–2 cm. long, membranous, sometimes purple-tinged, conspicuously 10-nerved (nerves purple), glandular-puberulent, the hairs frequently pigmented, lobes oblong-ovate, obtuse, 4 (3)–6 mm. long, glandular-ciliolate; corolla conspicuously exserted, pink to rose-purple, petals 2 (1.5)–3 cm. long, the blade broadly cuneate, irregularly toothed, shallowly lobed, or 4-cleft into linear-oblanceolate lobes, the lateral smaller, appendages inconspicuous, claws broad, gradually narrowed to the base; capsule ovate-oblong, somewhat shorter than the calyx, opening by 6 smooth valves, (rarely 4 or 5), stipe 1–2 mm. long, styles 3; seed 2–2.5 mm. broad, laterally compressed, brown, with a conspicuous broad marginal crest of bullate tubercles.

Type. Common on steep, loose, bare, calcareous slopes at 10,900 feet, Skyline Drive, one mile above Baldy Ranger Station, Manti National Forest, Sanpete County, Utah, August 8, 1940, *Bassett Maguire 20000* (Utah State College). Cotypes. Loose calcareous sand-clay rim, frequent at 10,500 feet, one-half mile east of museum, Cedar Breaks National Monument, Iron County, Utah, July 12, 1940, *Bassett Maguire 19465;* frequent in bare gravelly clay on rapidly eroding slopes, Red Canyon, Garfield County, Utah, July 16, 1940, *Bassett Maguire 19550.*

Other collections. UTAH. Iron County: Cedar Breaks, August 12, 1938, *Hitchcock, Rethke & van Raadshooven 4582,* August 7, 1934, *Maguire 17977,* August 13, 1939, *Maguire 17566,* June 23, 1940, *Maguire 19019,* July 12, 1940, *Maguire 19481,* August 18, 1940, *R. T. Clausen & H. Trapido 5109.* Garfield County: Red Canyon, August 9, 1934, *Maguire 17987,* June 25, 1940, *Maguire 19060,*

July 16, 1940, *Maguire 19533,* July 16, 1940, *Maguire 19556;* Pink Cliffs at 9000 feet, Table Cliff Plateau, Powell National Forest, June 26, 1940, *Maguire 19121.* Sanpete County: Sky Line Drive, August 8, 1940, *Maguire 19989,* August 8, 1940, *Maguire 20001* (topotypes).

It is fitting that this attractive new *Silene* be named in honor of Dr. E. G. Peterson, President of Utah State Agricultural College, who made possible the establishment of this herbarium, and who since, by constant sympathy and personal encouragement has been most helpful in the progress of its work.

LYCHNIS DRUMMONDII (Hook.) Wats. In Utah and the Great Basin the tall-stemmed *Lychnis* has been recognized as representing the three following species: *L. Drummondii,* with "included corolla" and "sessile capsule"; *L. nuda,* with "exserted, 4-lobed petals," "inflated obovate calyx," and "stipitate capsule"; and *L. striata,* with "exserted 2-lobed petals," "oblong calyx" and "sessile ovary."

Specimens recently collected in Utah show these characters in the following combinations, but with all degrees of intermediacy obtaining. Plants of the latter characters show no ecological or geographical segregation, hence are at most only varietally distinct: (a) corolla more or less included, petals bifid or lobed, ovary subsessile or short-stipitate, calyx ovate-oblong; (b) corolla more or less exserted, petals (2-) 4-cleft or lobed, ovary subsessile or short-stipitate, calyx ovate-oblong.

Robinson (4) reduced *Lychnis nuda* Wats. to *Silene pectinata* var. *subnuda,* citing the Watson Humboldt Mountains collection and, without number, two collections of M. E. Jones: "Near Empire City and at Franktown, Nev." A collection from Empire City, Nevada (June 19, 1882, *M. E. Jones 3795,* Utah State College no. 5746), although immature, is without question *Lychnis* and probably represents part of the series cited by Robinson. It would seem then that Robinson was probably in error in the transfer. Tidestrom (5, p. 200) accepted the name of Watson as representing a valid species. Nelson (3) reduced the name *L. striata* to synonomy under *L. Drummondii.*

The writer has not seen the type of *Lychnis nuda* and realizes that the "inflated calyx" does not obtain in *L. Drummondii.* However, since the Utah material, which surely represents but a single major species, transcends the characterization of these three formerly proposed entities, it seems best to treat the plants with exserted and mostly 4-lobed or 4-cleft petals as a variety:

LYCHNIS DRUMMONDII (Hook.) Wats. var. nuda comb. nov. *L. nuda* Wats. in King, Geol. Expl. 40th Par. 5: 37. 1871. *L. striata* Rydb. Bull. Torr. Club 31: 408. 1904.

Utah State Agricultural College,
Logan, Utah, April, 1940.

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A NEW LIMNANTHES FROM OREGON

LEROY ABRAMS

Limnanthes Howelliana sp. nov. Caules ex basi 1 vel plures, 12–25 cm. alti, succulenti, glabri. Folia glabra, infera 5–8 cm. longa, infra divisionibus 2- ad 3-lobatis, supra integris, lineari-oblongis vel linearibus; sepala lanceolata, acuta, 7–8 mm. longa, glabra; petala alba, basi flava, obovata, emarginata, 12–16 mm. longa, apice subtruncato et late emarginato, infra 9-nervia, infra medium sparsim longo-villosa; carpella dense obtuso-tuberculata.

Stems one to several from the base, 15–25 cm. high, rather succulent, glabrous. Leaves glabrous, the lower 5–8 cm. long, lower divisions 2- to 3-lobed, the upper entire, linear-oblong or linear; sepals lanceolate, acute, 7–8 mm. long, glabrous; petals white with yellow base, obovate, emarginate, 12–16 mm. long, 6–7 mm. wide at the subtruncate broadly emarginate apex, 9-nerved below, sparsely long-villous below the middle; nutlets thickly beset all over with broad mammillate tubercles.

Type. Roadsides and fields near Wilbur, Douglas County, Oregon, April 8, 1894, *J. W. Thompson 10161* (Dudley Herbarium 230576). Other collections of this species in Dudley Herbarium are: ditch north of Oakland, *J. W. Thompson 4390;* Yoncalla, *J. W. Thompson 186*. All of these stations are in Douglas County on the Umpqua River watershed.

Thomas Howell gave a good description of this species in his "Flora of Northwest America" under the name *Limnanthes Douglasii* R. Br. and I therefore take pleasure in naming it in his honor. It differs from *L. Douglasii,* a species of the Coast Ranges of central and northern California, in several characters. The nutlets of that species are smooth or crowned at the apex with a few tubercles, the leaflets or divisions several-toothed or -lobed, whereas in *L. Howelliana* they are entire or the lower 3-lobed, as in *L. alba* Hartw. *Limnanthes rosea* Hartw. has the nutlets thickly beset all over with protuberances, but they are thin, scale-like and whitish.

Four other species of *Limnanthes* have been described from southern Oregon: *L. Bellingeriana* M. E. Peck, *L. floccosa* Howell, *L. gracilis* Howell, and *L. pumila* Howell.

Dudley Herbarium, Stanford University,
California, February 5, 1940.

REVIEWS

The Cacti of Arizona. By Lyman Benson, J. J. Thornber, and A. A. Nichol, with line drawings and three color plates by Lucretia Breazeale Hamilton. University of Arizona Bulletin volume 11, no. 1, pp. 1–134, with 52 plates, 6 in full color, and colored frontispiece. (Biological Science Bulletin no. 4 [or 5?]) University of Arizona, Tucson, Arizona, January, 1940. $1.00.

This semipopular bulletin on the cacti of Arizona was published to fill the place left vacant by the exhaustion of the supply of Biological Science Bulletin no. 1, by Stockwell and Breazeale, issued in 1933. The discrepancy between the bulletin number shown on the cover and that appearing on the title page is puzzling, for the cover bears the legend "Biological Science Bulletin No. 5" while on the title page it is called "Biological Science Bulletin No. 4." One also wonders about the date, January 1, 1940, although it is not impossible that the bulk of the stock of bulletins was not distributed until some eleven months later.

However, these minor details detract not one whit from the value of this handbook of the Arizona cacti. It is well planned, carefully written, and beautifully illustrated with plates in full color, half-tone, and line drawings. The profuse use of illustrations fulfills the authors' hope that ". . . the more common cacti may be recognized without resort to the keys." The keys are formal, dichotomously constructed and workable. The number of technical terms used in keys and descriptions has been held to just about the minimum, and those used, tersely defined in a short glossary or in the introductory paragraphs.

Distribution maps show the range, within Arizona, of sixty of the more important species recognized as occurring within the state. It is regrettable that the base maps, upon which the distribution is shown in green, were not drawn with bolder lines and with fewer intricate topographical details, for one must compare them with larger scale maps to determine with any assurance the position of many of the limits of distribution. The maps are valuable in that in spite of the indistinct details they graphically present the general distribution of the species so treated.

The taxonomic treatment of the genera is conservative, *Carnegiea, Lophocereus, Lemaireocereus, Peniocereus,* and *Wilcoxia* all being lumped in the older genus *Cereus.* In like manner, *Echinocactus* becomes the repository for *Ferocactus, Echinomastus, Sclerocactus, Utahia,* and *Toumeya,* while *Coryphantha, Escobaria,* and *Phellosperma* are relegated to synonymy under *Mamillaria.* This is in keeping with the generic treatment of these groups by several Europeans who have dealt with the cacti during the past decade, and may reflect a reaction to the criticism occasionally voiced concerning the treatment of Britton and Rose to the effect that these two gentlemen recognized too many genera and too few species. The authors' concept of species seems to be more liberal than their definition of genera, for they recognize ten species of

Echinocereus, the validity of some of which has been questioned by cactus fanciers who usually allow quite narrow specific delimitations. Again, both *Opuntia ursina* and *O. erinacea* are given full specific value. (I'd do the same myself.) In other instances they have refrained from attempting to evaluate some of the more troublesome complexes in *Opuntia* and *Mamillaria,* frankly stating that several more years of critical study must be given these puzzling groups. In spite of what one's personal opinion may be concerning the treatment of the genera, the taxonomic treatment in this book is a practical one and doubtless will prove admirably "usable" to many westerners and travelers interested in the southwestern flora. The first hand information supplied by these men who have studied the cacti of Arizona at all seasons will be most valuable to botanists to whom opportunities for field work in the Southwest come infrequently.

The brief section dealing with the culture and care of cacti is sufficient for handling most of the native species. A. A. Nichol, who wrote this section of the book, refrained from giving detailed specifications, but included the necessary general hints covering the soil, water and light requirements of most of the Arizona cacti.

The book is well printed on glazed paper, with paper cover, and at the modest price of one dollar should find wide acceptance among botanists and cactus growers. The illustrations make it an excellent book for the non-professional who is interested in making a "speaking acquaintance" with the dwellers of the arid Southwest.—Ira L. Wiggins, Dudley Herbarium, Stanford University.

Flora of Indiana. By Charles C. Deam. Department of Conservation, Division of Forestry. Pp. 1–1236, maps 1–2243, 4 unnumbered maps and frontispiece. Indianapolis, Indiana. 1940. $3.50. (Send order to State Forester, State Library, Indianapolis, Indiana.)

Dr. Deam has set a new high standard for regional floras. This volume will be a constant source of reference not only for students of the Indiana flora but for all those engaged in floristic studies. Every effort has been made to present a complete and accurate picture of the flora of Indiana. Dr. Deam has incorporated the results of field studies carried on through years of travel. Every species listed in the flora is based upon actual and accessible specimens and in many cases the identifications have been checked by specialists. Certain parts of the text have been contributed: the genera *Carex, Juncus* and *Luzula* by Frederick J. Hermann; Chenopodiaceae by Theodor Just; *Crataegus* by Ernest J. Palmer. Distribution maps are included for each species. These maps show not only the location but also the time of flowering and the herbaria in which the specimens are located.

The author has included a discussion of the floral areas of Indiana; a list of names of collecting places; a reference list of

Indiana collectors; and a bibliography of the Indiana flora. Ecological notes are given for many of the species and since these are based on the author's own observations they are of particular value.

The flora will undoubtedly be considered a model of excellence and thoroughness. Every student and writer of floras will do well to consult it not only as a model of form but because of the invaluable information which it contains. Such a volume should be a constant companion in the field; it is to be regretted that it was impossible to publish all this material in a form more suitable for field use.—Mildred E. Mathias, Department of Botany, University of California, Berkeley, California.

NOTES AND NEWS

Ribes petiolare dougl. in California. Occurring generally along streams and on moist sites from British Columbia south through the intermountain region to southern Oregon and Arizona, *Ribes petiolare* was first reported from California by George A. Root in 1937 (California Ranger 8^9: 4, 1937). The species was found by Root and Hollis Day along Shovel Creek in Shasta National Forest, Siskiyou County, about nine miles south of the California-Oregon boundary line. In the same report Root mentions finding a few bushes of *R. petiolare* one and one-half miles north of the boundary line on Kelley Creek near Lakeview, Lake County, Oregon, at the northern end of the Warner Mountains; he did not see it farther south in Modoc National Forest, California. In reviewing Root's report, Clarence R. Quick (Madroño 4: 286–290. 1938) mentions observing *R. petiolare* in abundance on Crane Creek a few miles north of Kelley Creek in Oregon; he also was unsuccessful in finding the species south of the line in the Warner Mountains.

In July, 1939, the writer, while examining specimens in the herbarium of the United States Forest Service at Alturas, California, noted a collection of *Ribes petiolare* from "Lost Lake-Silver Creek" in the southern Warner Mountains, Modoc National Forest, made August 13, 1918, by Associate Forester L. S. Smith. It bore the numbers 1033 and 31510, the latter the accession number of the Herbarium of the United States Forest Service, Washington, D. C., to which Mr. Smith sent a portion of his collection. Dr. Frederick V. Coville verified the determination. The following herbaria have been consulted for records or specimens, but with negative results: University of California, Berkeley, California Academy of Sciences, Stanford University, United States Forest Service and Division of Plant Exploration and Introduction, Washington, D. C. Apparently Mr. Smith's collection constitutes the earliest known record of the species in California and establishes its occurrence approximately seventy miles south of the Oregon line.

Additional specimens were obtained by G. A. Zentmyer and the writer from the same locality, July 30, 1939, and a portion of this collection has been deposited in the Herbarium of the University of California, Berkeley. The species was observed in abundance along Silver Creek and several of its tributaries about one-half mile southwest of Lost Lake (particularly in Sec. 15, T.38 N., R.16E., Mt. Diablo Meridian). It was not found by the writer north of this locality in the Warner Mountains.

The occurrence of *Ribes petiolare* near Lost Lake is considered of significance from the standpoint of blister rust control. The species is one of the most susceptible of western currants and dense concentrations of the bushes grow there in close association with an abundance of whitebark pine (*Pinus albicaulis* Engelm.), which according to present information is considerably more susceptible than other western white pines. The rust, however, was not found on either pines or currants at this place.—J. L. Mielke, Division of Forest Pathology, Bureau of Plant Industry, United States Department of Agriculture, San Francisco, California.

In a recent issue of "Science" appeared an announcement of the death on August 20, 1940, of Dr. Joseph Burtt-Davy, lecturer in tropical botany at the Imperial Forestry Institute, Oxford. From 1893 to 1903 Dr. Burtt-Davy was connected with the University of California, first as a student assistant, later as instructor in botany and assistant botanist in the Agricultural Experiment Station. He left California to accept an appointment as agrostologist and botanist in the Department of Agriculture, Pretoria, South Africa. Soon after the close of the World War he returned to England and was for some time engaged in the preparation of "A manual of the flowering plants and ferns of the Transvaal with Swaziland, South Africa," parts one and two of which were published in 1926 and 1932 respectively. During his sojourn in California Dr. Burtt-Davy, in connection with his studies on agronomy, visited many parts of the state and made collection of grasses and other forage plants; these collections, amounting to about two thousand numbers, are deposited in the University of California Herbarium. From 1896 to 1900 he published a number of articles in "Gardeners' Chronicle," "The Pacific Rural Press," and as bulletins of the University of California Agricultural Experiment Station and the United State Department of Agriculture; he also contributed more than fifty short articles to "Erythea." While in Berkeley he married Alice Bolton. Dr. Burtt-Davy is well remembered by the older faculty members of the University of California.

Important monographic studies published during the current year and not previously noted in Madroño are: "the genus *Ellisia*," by Lincoln Constance (Rhodora 42: 38–39. 1940); "the genus *Dichelostemma*," by Robert F. Hoover (Am. Midland Nat. 24: 463–

476. 1940); "studies in *Penstemon* VII, the subsections Gairdneriani, Duesti, and Arenarii of the Graciles . . . ," by David D. Keck (Am. Midland Nat. 23: 594–616. 1940); "a revision of the North American species of the genus *Thermopsis*," by M. M. Larisey (Ann. Mo. Bot. Gard. 27: 245–258. 1940); "a monograph of the genus *Symphoricarpos*," by George Neville Jones (Journ. Arnold Arbor. 21: 201–252. 1940); "studies in the genus *Hedysarum* in North America," by R. C. Rollins (Rhodora 42: 217–239. pl. 597. 1940); "*Spergularia* in North and South America," by R. P. Rossbach (Rhodora 42: 57–83, 158–193, 203–213. pls. 589–596. 1940).—Ethel Crum.

Approximately five-hundred fifty species and varieties of native Californian and cultivated trees are included in a recent publication "Trees of Santa Barbara" by Maunsell Van Renssaeler of the Santa Barbara Botanic Garden, California. Descriptions are brief and non-technical and exact locations of more than eight-hundred specimen trees are given. For convenient reference genera are arranged alphabetically, and both common and scientific names are listed in the index. The book of 141 pages is very attractive in format and is illustrated by a large number of excellent photographs and line drawings. Among those represented by full page photographs are the following native Californian species: *Ceanothus arboreus, Fremontia mexicana, Lyonothamnus asplenifolius, Pinus Torreyana, Platanus racemosa.* (Price: paper, $.75, cloth, $1.50.)—Ethel Crum.

Under the title "Alien plants growing without cultivation in California," Dr. W. W. Robbins lists approximately 526 species with comment as to the dates of their introduction into California, their habitats and distribution and their importance as weeds or forage. The pamphlet consists of 128 pages of which thirteen are devoted to introductory discussion, ninety-eight to comment on the species, seven to literature cited and fourteen to a comprehensive index of common and scientific names. The publication appeared July, 1940, as Bulletin 637 of the Agricultural Experiment Station, University of California, Berkeley.

At the Thirty-Fifth Annual Meeting of the Botanical Society of America, December 28, 1940 to January 1, 1941, Philadelphia, papers by the following botanists of western states were scheduled: E. L. Little, Southwestern Forest and Range Station, Arizona; James Bonner, J. van Overbeck, California Institute of Technology; D. L. Arnon, Ernest Ball, Donald E. Bliss, R. W. Chaney, R. E. Clausen, Lincoln Constance, Frank Cuneo, Carl Epling, Katherine Esau, A. S. Foster, D. R. Hoagland, Flora Murray Scott, F. M. Turrell, University of California; G. H. Rossbach, Stanford University; Joseph Ewan, University of Colorado.

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Contents

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VARIATION IN YUCCA WHIPPLEI

Lee Haines

Yucca Whipplei, a species which is widespread and abundant in southern California, is a member of the family Agavaceae Hutchinson. It ranges from Laguna Seca Chapala in northern Lower California (29° 30′ N. Lat.) to Chew's Ridge in Monterey County, California (36° 30′ N. Lat.). The species varies greatly in appearance and it is apparent from casual observation that the variants are geographical in some degree. However, the nature of the genus *Yucca* is such that this variation can be studied adequately only in the field. Few herbarium specimens exist and these afford at best only the most general information as to the nature of the plant. The investigation has accordingly been carried on solely in the field. This was particularly necessary since it was found from preliminary observations that the size and conformation of the flower and fruit have essentially the same degree of variability throughout the species and that any conclusions must perforce be drawn from a comparative quantitative study of the vegetative characteristics and habit of the inflorescence.

The author acknowledges his indebtedness to the board of graduate research of the University of California, Los Angeles, for funds with which the extended field work was carried on and his gratitude to Dr. Carl Epling, under whose guidance this work was done, to Dr. H. G. MacMillan for help in the preparation of the figures and to many colleagues for assistance in the field.

Distribution

Before any observations or measurements could be made, it was necessary to discover where, in the vast area within its limits, *Yucca Whipplei* grows. The distribution area was divided into geographic sections and reconnoitered in an automobile by traversing as many of the highways, secondary roads, fire roads, and truck-trails as possible. By traveling approximately four thousand miles, the entire area was surveyed and the approximate distribution limits of the species were established (fig. 1). During this reconnaissance, stops were made at favorable localities and observations and measurements were recorded. Such a locality was treated as a field station, designated by a number, and located on a topographic map.

In Lower California the distribution has not been determined in detail. The species was observed at the Laguna Seca Chapala, in the mountains east of Rosario, in the chaparral-covered coastal hills near Sacaton between Ensenada and San Vicente, and north of Ensenada. In southern California it is found in the mountains from Campo northward through the Laguna and Balkan moun-

Madroño, Vol. 6, pp. 33–64. April 15, 1941.

tains to the San Jacinto and Santa Ana mountains. It is continuous in a narrow strip from the San Jacinto Mountains to the San Bernardino, San Gabriel, Santa Susana, and Santa Monica mountains to Mount Piños and the Tehachapi mountains. Here the area divides, one branch extending northward in the Piute and

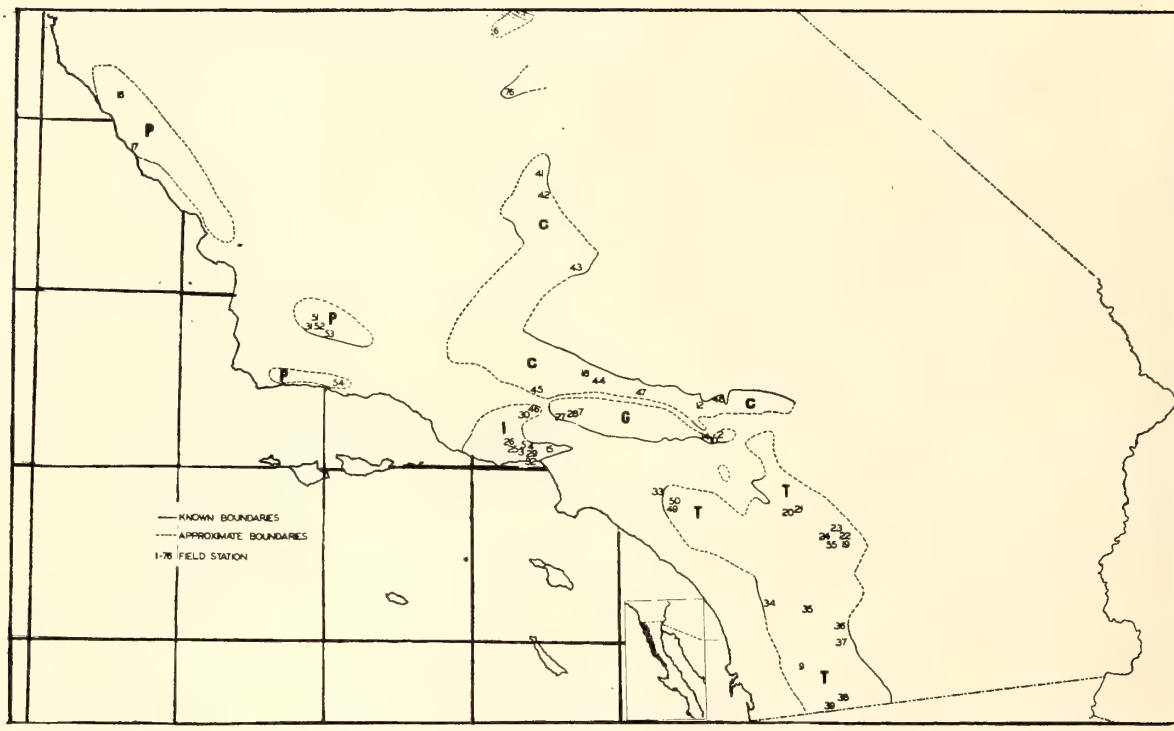

FIG. 1. Distribution of *Yucca Whipplei* in California and Baja California. G, subsp. *Parishii;* P, subsp. *percursa;* I, subsp. *intermedia;* C, subsp. *caespitosa;* T, subsp. *typica.*

Greenhorn mountains and to the western margin of Sequoia National Park, the other passing northward through the Santa Ynez, San Rafael, and Santa Lucia mountains to Chew's Ridge, north of Tassajara Hot Springs in Monterey County. The species is maritime from the Santa Monica Mountains northward. Southward from Walker Pass to the eastern end of the San Bernardino Mountains, it occurs on the margin of the Mojave Desert.

The distribution of *Yucca Whipplei* is not continuous throughout its range. There are major gaps between the Santa Ana and the Santa Monica mountains, between the Santa Monica and the Santa Ynez mountains, between the San Rafael and the Santa Lucia mountains, and between the Walker Pass region and the region along the western border of Sequoia National Park. Within these lesser areas the species is either diffuse and general or may be localized. Throughout its entire range *Yucca Whipplei* usually occurs in very porous, shallow soil or on rocky outcrops at elevations from sea level up to 6000 or 8000 feet. When growing on ridges or walls it is found on slopes which have an exposure toward the south.

Growth-Forms

It soon became apparent from field observation that at least four types of growth-forms exist in this species and that these forms are correlated with the geographic distribution. These growth-forms may be briefly characterized as follows: (1) a soli-

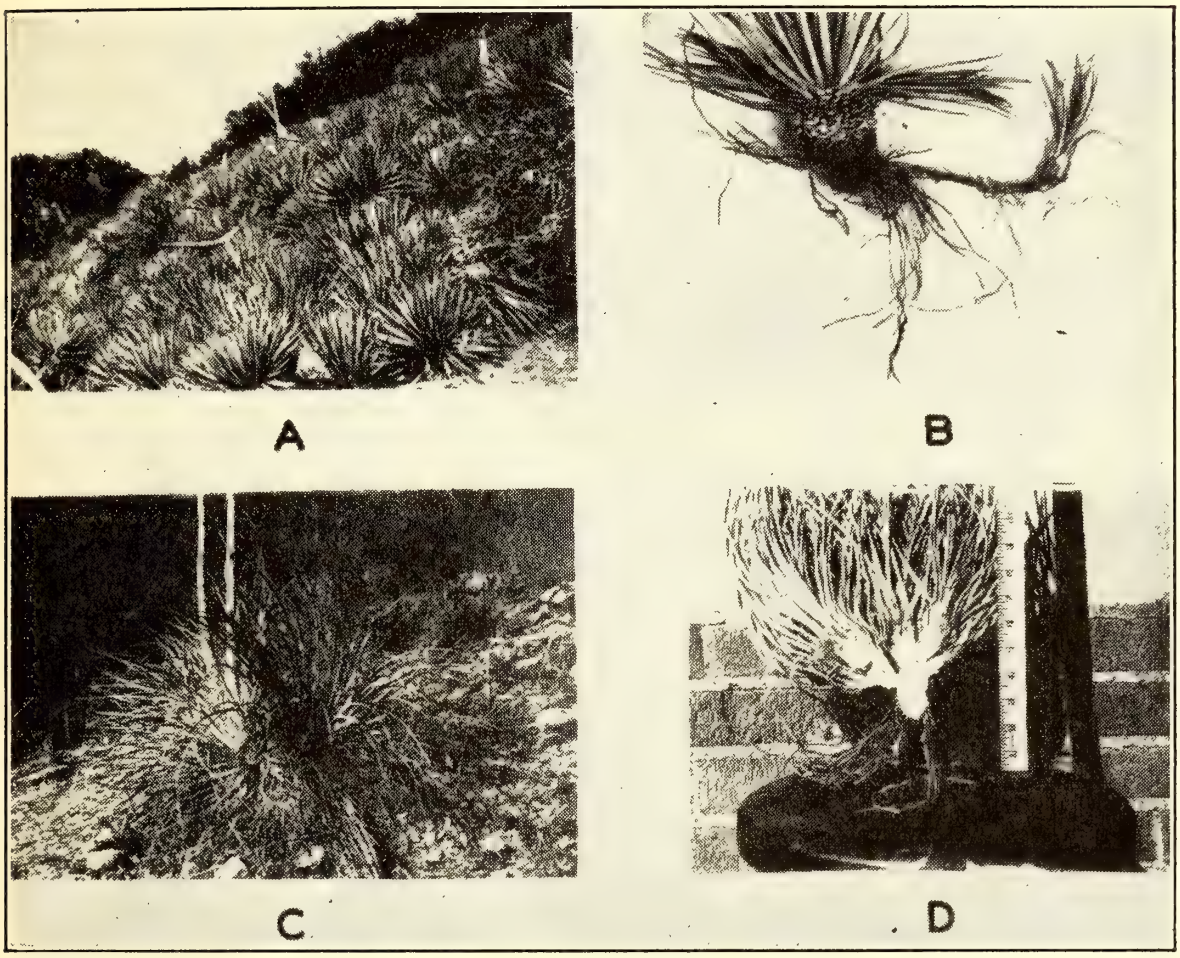

Fig. 2. *Yucca Whipplei.* A, a colony, perhaps a single clone, of subsp. *percursa,* San Rafael Mountains. B, a single plant from such a colony showing a short newly developed rhizome. C, an individual of subsp. *intermedia,* Santa Monica Mountains. The branch on the left has died back after flowering, that on the right has developed from an axillary bud on the dead branch. D, a small specimen of subsp. *caespitosa* from Walker Pass showing the method of branching from the original stem. Such proliferation may continue before flowering takes place until a clump of a hundred or more rosettes is formed.

tary form, with a simple unbranched, bulbous stem which dies as soon as the plant has flowered; (2) a caespitose form in which the stem branches on the surface of the ground to form a clump of plants composed of from four to one hundred or more distinct rosettes, several of which may send up flower stalks in the same season; in this case, numerous rosettes are formed before any flowering takes place (fig. 2, D); (3) a caespitose form, occasionally solitary, in which the stem branches by means of axillary buds which form short lateral branches; in this case new rosettes are usually formed only after flowering and the dying back of a

branch; one or several rosettes may thus be formed, but only one flower stalk is usually produced in any given season (fig. 2, C); and (4) a rhizomatous form, the stem branching by means of underground rhizomes to form dense colonies of asexually produced individuals (fig. 2, A, B).

The solitary form (1) occurs in San Diego, Riverside, Orange, San Bernardino, and Los Angeles counties in two regions which are geographically isolated. They are indicated in Figure 1 by the letters "T" and "G." Actually each of these regions is occupied by a distinct form which may be segregated on the basis of size. The caespitose form (2) with many rosettes, of which several flower in each season, occurs on the western margin of the Mojave Desert from the San Bernardino Mountains east and north to Tehachapi Pass and from there into the Piute and Greenhorn mountains. The distribution of this form is indicated in Figure 1 by the letter "C." The caespitose form with few rosettes (3), only one flowering in each season, occurs throughout the Santa Monica and Santa Susana mountains in the area marked "I." The rhizomatous form (4) occurs in the San Rafael, Santa Ynez and Santa Lucia mountains; its distribution is indicated in Figure 1 by "P". The only point at which any of these races are known to merge and exhibit intermediates lies in the Cajon Pass area where hybridization is apparently frequent between the solitary montane form and the caespitose desert form. There are also two isolated regions in the southern Sierra in which *Yucca Whipplei* grows: along the western border of Sequoia National Park and on the Middle Fork of the Tule River in the Sierra Nevada foothills. The data regarding these two localities are incomplete and the plants growing there (as well as those of Lower California) have been eliminated from present consideration. It seems probable, that although the proportions are similar to those of the solitary form, they are distinct and form another subspecies because of the nature of branching.

Variation of Inflorescence and Leaves

After discovering that the members of this species possessed four forms of growth habit, the question arose as to whether the morphology of the inflorescence and proportions of the whole plant might not be correlated with the growth habit and geographic distribution. The answer to this question is based upon a statistical treatment of the measurements taken at each field station.

The following characters were recorded for each of 1114 plants studied in the field (certain other characters were also recorded, but these were found not significant for the present purposes): (1) the height of the flower stalk, (2) the length of the panicle, (3) diameter of the panicle at its widest point, (4) the diameter of the flower stalk as measured one meter above the surface of the ground, and (5) the length of the leaves. The measurement of characters (1) and (2) were made to the nearest six inches,

while character (3) was measured to the nearest inch. At a point one meter above the ground level, the diameter of the flower stalk (4) was measured with outside calipers to the nearest eighth of an inch. The length of the leaf (5) was measured to the nearest inch (fig. 3, C).

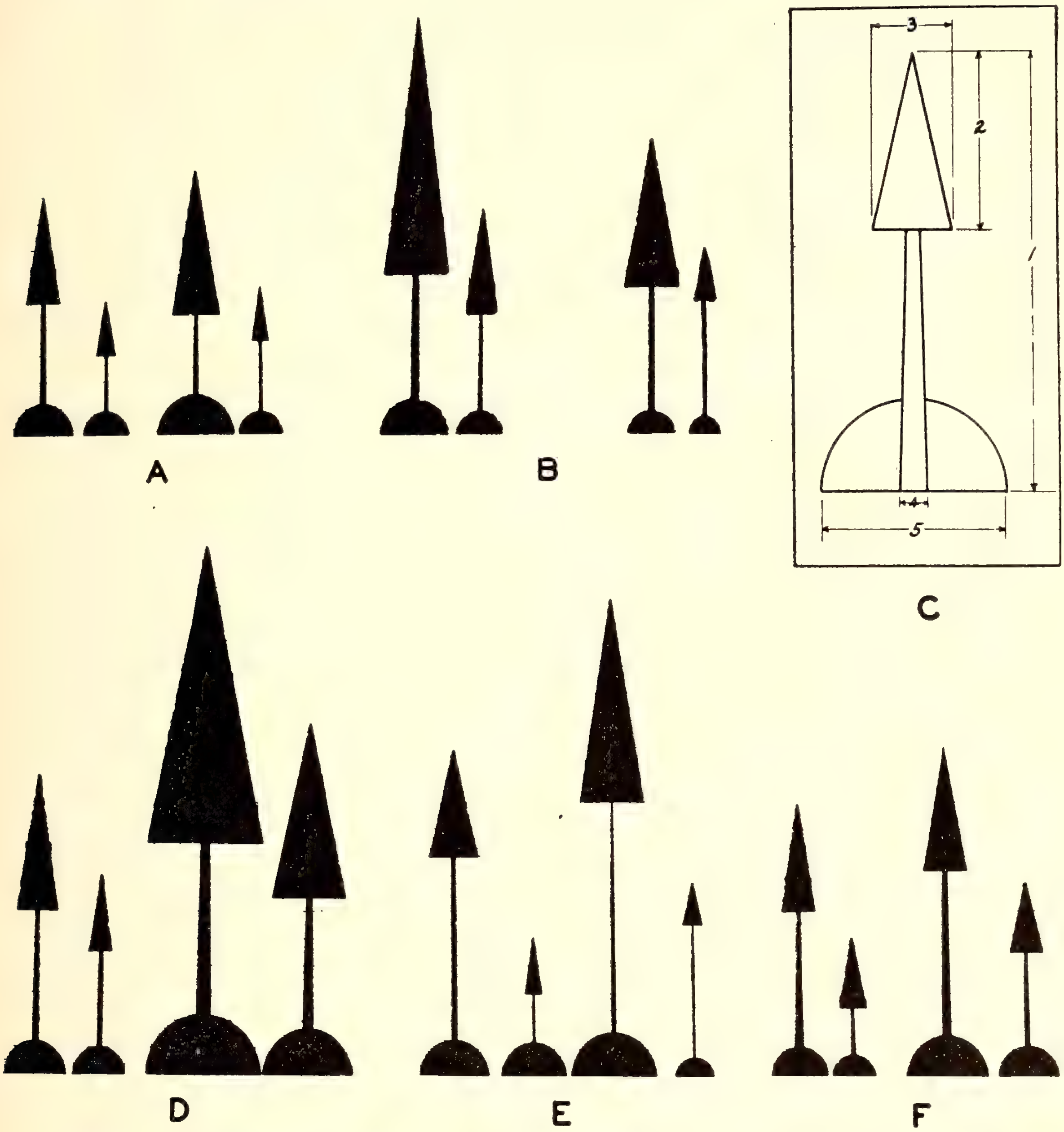

FIG. 3. Ideographs which summarize the measurements made upon twenty plants of *Yucca Whipplei* from ten stations. Each pair of stations is from the same geographic region and was so chosen as to illustrate the extremes of variation measured in that region. A, subsp. *caespitosa;* B, subsp. *percursa;* D, subsp. *Parishii;* E, subsp. *intermedia;* F, subsp. *typica.* The dimensions measured are shown in C. The stations follow: A, left, station 43, eight miles northwest of Mojave, Kern County; A, right, station 47, 1 mile above Valyermo; B, left, station 16, Santa Lucia Memorial Camp, Monterey County; B, right, station 51, 5 miles north of Los Olivos, Santa Barbara County; D, left, Arrowhead Springs, San Bernardino County; D, right, station 28, Tujunga Wash, Los Angeles County; E, left, station 26, Malibu Lake, Los Angeles County; E, right, station 15, West Los Angeles; F, left, station 35, 2 miles south of Lake Henshaw, San Diego County; F, right, station 21, 10 miles east of Hemet, Riverside County.

TABLE 1

Arithmetic Means for Measurements of Morphological Characters of *Yucca Whipplei* from Each Field Station, Showing the Total Range of Variation in the Species

Field Station Number	Number of Plants	Height of Flower Stalk in Feet	Length of Panicle in Feet	Diameter of Panicle in Inches	Diameter of Flower Stalk in Inches	Length of Leaves in Inches
4	16	8.47	3.53	13.80	1.23	21.70
6	14	13.90	6.46	21.70	3.21	34.00
7	12	12.40	5.58	34.20	3.16	29.50
8	12	13.00	6.33	25.10	3.02	28.50
9	17	7.35	2.70	11.10	1.83	25.00
10	19	9.65	4.02	11.70	2.59	25.90
12	12	9.07	4.17	13.30	1.96	22.40
13	12	8.71	3.92	14.90	1.87	21.40
14	12	12.67	6.20	12.67	3.02	31.00
15	48	10.45	3.65	17.35	1.42	28.74
16	24	11.45	5.95	21.60	2.70	24.33
17	24	10.30	4.94	16.60	1.79	25.70
18	36	7.65	3.54	12.10	1.88	21.00
19	16	9.80	4.15	19.00	3.42	25.50
20	12	8.70	3.30	14.50	2.33	32.00
21	12	10.00	4.30	14.75	2.26	28.70
22	25	9.20	3.83	14.80	3.23	21.40
23	12	9.65	4.00	16.20	3.21	24.00
24	12	8.76	4.16	17.40	3.16	24.00
25	48	7.15	2.98	13.40	1.00	24.20
26	52	8.60	3.27	14.10	1.10	26.30
27	12	17.40	9.33	33.90	4.71	29.00
28	12	16.36	8.96	32.40	4.20	32.50
29	53	9.93	3.87	17.30	1.42	28.45
30	36	9.13	3.88	14.80	1.31	25.80
31	36	9.70	5.03	16.03	2.44	16.47
32	13	10.20	3.96	16.05	1.34	30.15
33	12	7.68	2.72	9.35	1.39	25.80
34	12	8.90	3.22	12.60	1.43	29.30
35	24	6.90	2.87	11.10	1.46	20.30
36	12	6.92	3.08	12.67	1.58	21.70
37	12	9.00	4.21	16.40	2.81	26.20
38	12	6.50	2.67	10.20	1.28	21.50
39	12	6.45	2.46	11.20	1.23	21.20
40	24	8.70	3.50	15.50	1.22	33.40
41	26	6.60	2.54	10.00	1.00	20.20
42	24	9.05	3.62	14.20	1.44	25.50
43	36	6.54	2.56	9.75	1.26	22.60
44	12	6.50	2.85	9.60	1.00	18.20
45	12	8.75	3.62	15.30	1.25	29.60
46	12	9.17	4.20	17.85	1.36	29.60
47	25	8.42	3.58	16.95	1.23	18.70
48	25	5.90	2.78	9.16	.86	18.52
49	36	7.90	3.30	10.80	1.57	23.60
50	13	8.48	3.38	12.10	1.56	22.20
51	25	9.18	4.42	15.90	2.09	17.30
52	25	8.88	4.44	16.16	1.89	16.44
53	50	7.91	3.61	13.50	1.62	16.04
54	17	9.60	4.26	15.50	1.88	22.60
76	48	15.10	7.86	23.90	3.64	43.00

In Table 1 are listed the field stations whose locations are indicated by number in Figure 1 together with the number of plants measured at each station and the average value of each of

TABLE 2

Arithmetic Mean, Standard Deviation and Standard Error of the Mean for the Characters Measured and Segregated by Geographic Regions and Growth-Forms

Yucca Whipplei Subspecies	Height of Flower Stalk	Length of Panicle	Diameter of Panicle	Diameter of Flower Stalk	Length of Leaves
caespitosa, C	7.58 ± .102	3.27 ± .587	12.06 ± .247	1.31 ± .028	23.13 ± .340
typica, T	8.32 ± .103	3.14 ± .060	13.30 ± .240	2.14 ± .050	23.93 ± .330
Parishii, G	13.16 ± .369	4.40 ± .253	23.46 ± .942	3.35 ± .109	28.98 ± .637
intermedia, I	9.27 ± .144	3.62 ± .662	15.42 ± .275	1.22 ± .162	26.68 ± .305
percursa, P	9.33 ± .170	4.62 ± .813	16.90 ± .292	1.99 ± .392	18.87 ± .349

these five characters. The data given in Table 1 show the mean measurements for each station but not the range; that is, the differences between two plants which might be found growing side by side. The ideographs shown in Figure 3 will give an approximate idea of this range, that is, the amount of variation at a given station. The proportions of the individuals, as determined by the measurements indicated, are reconstructed in the ideographs, a method suggested by Edgar Anderson (Ann. Mo. Bot. Gard. 15: 241–332. 1938). Each of the ideographs in Figure 3 represents an individual plant from one of the five geographic regions indicated in Figure 1. The left pair of ideographs in each figure represents the largest and smallest plants found at one station, the right pair of ideographs in each figure, the largest and smallest plants found at a second, but widely separated, station within the same geographic region. These have been selected in such a way as to illustrate the extremes of variation found in each of the five geographical regions.

The arithmetic mean, the standard deviation and standard error of the mean were computed for each of the five characters of all the plants measured in each geographical region. These data are given in Table 2. From the arithmetic means ideographs were constructed which represent the mean proportions of the inflorescence and leaves of the yuccas of each of the five geographic regions. These are shown in Figure 4, where "G" represents the solitary form growing in the San Bernardino and San Gabriel mountains; "P" represents the rhizomatous form growing in the San Rafael, Santa Ynez and Santa Lucia mountains; "I" represents the caespitose form growing in the Santa Monica and Santa Susana mountains; "T" represents the solitary form growing in San Diego, Riverside and Orange counties; and

"C" represents the caespitose form growing on the western margin of the Mojave Desert.

These ideographs indicate that there is a recognizable difference in the mean morphology of the inflorescence and proportions of the vegetative parts which is correlated with the four forms of growth habit of the stem. This fact is consonant with and gives a quantitative expression of facts which had already been recognized intuitively from more or less casual observation. The differences between the two solitary forms "G" and "T" are so marked that the author proposes to separate them purely on the basis of the size and proportion of the inflorescence, particularly since the two forms are geographically segregated.

In order to determine whether the differences presented in Table 2 and Figure 4, are statistically significant, the standard

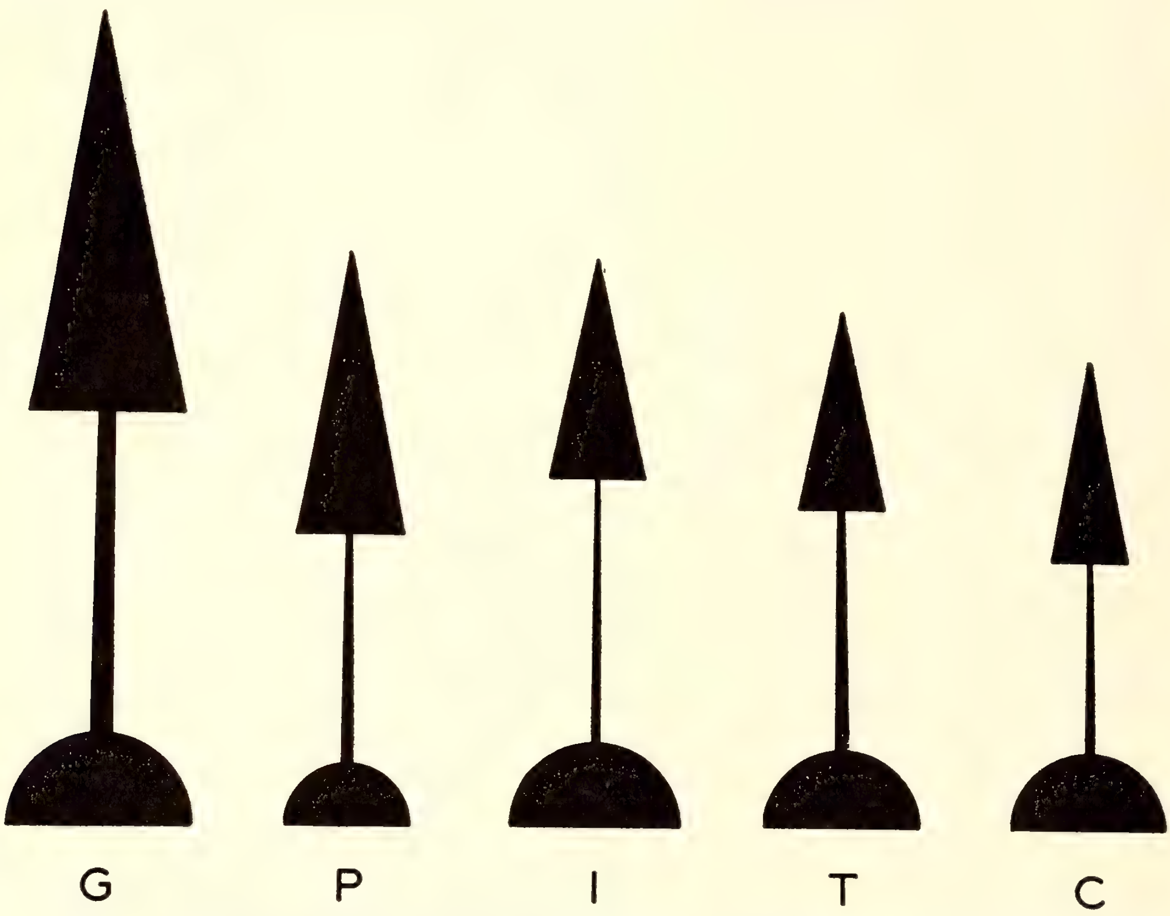

Fig. 4. Ideographs representing the mean proportions of five regional subspecies of *Yucca Whipplei*: G, subsp. *Parishii;* P, subsp. *percursa;* I, subsp. *intermedia;* T, subsp. *typica;* C, subsp. *caespitosa.*

error of difference was computed for the one hundred possible combinations of comparable characters represented in the ideographs. The resultant differences are recorded in Table 3, and expressed as critical ratios. When the critical ratio has a value greater than three, it is assumed that the differences between the means are statistically significant and that the characters measured may safely be considered as having arisen from sepa-

rate populations in which the true values for these characters are not alike.

TABLE 3

Critical Ratios Derived from the Standard Error of Difference between One Hundred Pairs of Means, as Shown

		typica	Parishii	intermedia	percursa	caespitosa
Parishii	h.F.S.		9.83	6.20	5.05	5.10
	l.Pan.		4.83	0.72*	1.81*	0.22*
	d.Pan.		10.45	5.80	9.55	3.58
	d.F.S.		10.10	5.45	0.38*	2.92
	l.Lvs.		7.05	6.13	10.40	1.69*
typica	h.F.S.			10.10	11.90	14.60
	l.Pan.			1.10*	0.25*	1.77*
	d.Pan.			8.20	6.66	11.70
	d.F.S.			10.90	3.34	182.00
	l.Lvs.			3.26	10.11	9.05
intermedia	h.F.S.				0.29*	11.05
	l.Pan.				0.74*	0.39*
	d.Pan.				3.70	9.10
	d.F.S.				1.82*	0.55*
	l.Lvs.				16.80	11.00
percursa	h.F.S.					8.83
	l.Pan.					0.77*
	d.Pan.					12.60
	d.F.S.					1.73*
	l.Lvs.					8.75

* Critical ratios which do not indicate a significant difference between the two means compared.

h.F.S.—height of flower stalk.
l.Pan.—length of panicle.
d.Pan.—diameter of panicle.
d.F.S.—diameter of flower stalk.
l.Lvs.—length of leaves.

While these ratios are statistically significant, their taxonomic significance must be interpreted largely upon the basis of experience. These critical ratios suggest that the order of significance of the morphological characters are: the diameter of the panicle, the height of the flower stalk, the length of the leaves, the diameter of the flower stalk, and the length of the panicle.

While some of the characters compared in Table 3 are not significantly different, the summation of habit which they express is. It is therefore clear that each geographic race or growth-form may be distinguished solely by mean size and proportions of its inflorescence and leaves.

Conclusion

It has been shown above that *Yucca Whipplei* is represented throughout its range by four growth-forms and that significant

differences of inflorescence and leaves are correlated with these growth-forms. Furthermore, it has been shown that one growth-form, the solitary type, is characteristic of two forms which differ significantly in habit of inflorescence and foliage and are geographically segregated. It appears, therefore, that *Yucca Whipplei* is represented by not less than five geographic races. That others may exist seems possible, in so far as the author is able to judge from the limited number of observations which were made on the forms of Lower California and the Sierra Nevada. The question arises, then, as to a suitable taxonomic treatment of these forms. It seems preferable, until there is evidence that more than geographic barriers segregate them, to treat the geographic races, discussed above, as subspecies.

Taxonomy

Yucca Whipplei Torrey, Botany of the Mexican Boundary 22, 1859, type collected by Schott at San Pasqual, San Diego County, California (Torrey Herb., N. Y. Bot. Gard.). *Y. aloifolia* Torrey in Report Whipple Exped., Botany 147, 1856 (not L.). Type collected in Cajon Pass by the Whipple Expedition; since two subspecies with intermediate hybrids occur here it is uncertain to which form this reference applies. *Hesperoyucca Whipplei* Baker in Kew Bull. p. 8, 1892.

Nearly acaulescent, stem simple or branched; leaves in a basal rosette, 0.125–0.75 inches wide, 1–4 feet long, linear-lanceolate, tipped with a slender spine, fibrous, evergreen, flat to more or less triquetrous, finely striate, their margins serrulate; inflorescence 5–20 feet high; panicle oblong, 1.5–11.5 feet long, 0.5–3 feet in diameter; peduncle 0.5–6 inches thick; perianth segments distinct, nearly equal; filaments clavate, attached to the base of the perianth; capsule short-cylindric, 1.5–2 inches long.

Key to the Subspecies

Stem branched, only the flowering branch dying back after flowering, both dead and living rosettes usually present.
- Stem branching by means of rhizomes, forming dense colonies of asexually produced individuals .... a. subsp. *percursa*
- Stem branching on surface of ground, forming a clump of from 4 to 100 or more rosettes; several inflorescences may arise from a clump of rosettes in a single season .... b. subsp. *caespitosa*
- Stem branching by axillary buds to form short lateral branches; only one inflorescence arises from a group of rosettes in a single season .... c. subsp. *intermedia*

Stem unbranched, solitary, the whole plant dying after flowering.
- Flower stalk 5–13 feet in height, 1–4.5 inches in diameter; panicle 1.5–7 feet in length, .5–2 feet in diameter; San Diego, Riverside and Orange counties and northern Lower California .... d. subsp. *typica*
- Flower stalk 7–20 feet in height, 1.5–6 inches in diameter; panicle 3–11.5 feet in length, 1–3 feet in diameter; San Gabriel and San Bernardino mountains ... e. subsp. *Parishii*

a. Yucca Whipplei subsp. **percursa** subsp. nov. Type collected on Cachuma Mountain in the San Rafael Mountains of Santa Barbara County, California, *A. L. Haines* (deposited in the Herbarium, University of California, Los Angeles).

Caudex longitudine 30–60 cm., in basi rhizomata elongata ferens et ut videtur clonum diffusum faciens; rhizomatibus maturis diametro circiter 2–3 cm., longitudine ad 2 m. et ultra; scapo altitudine ad 5 m. maximam partem circiter 3 m.; scapi in altitudine 1 m. supra humum diametro ad 8 cm., maximam partem 5 cm.; paniculis longitudine ad 3 cm., maximam partem circiter 1.5 m. et diametro in latissima parte ad 70 cm., maximam partem circiter 40 cm.; foliorum longitudine ad 1 m., maximam partem circiter 45 cm.

Stem 1 to 2 feet long, producing rhizomes at its lower end; mature rhizomes 1 inch in diameter, 2–6 or more feet in length producing new individuals from the terminal buds to form a dense stand which may be considered as a clone; height of flower stalk 5–16 feet, average 9.3 feet; diameter of flower stalk at one meter above ground .75–3.5 inches, average 1.9 inches; length of panicle, 2–9.5 feet, average 4.6 feet; diameter of panicle at widest point, 6–28 inches, average, 17 inches; length of leaves, 10–35 inches, average 19 inches.

This subspecies is a component of both the coastal sage and chaparral formations, occurring mostly between 200 and 2000 feet; it is found in the San Rafael, Santa Ynez and Santa Lucia mountains of Santa Barbara and Monterey counties.

b. Yucca Whipplei subsp. **caespitosa** comb. nov. *Y. Whipplei* var. *caespitosa* Jones, Contrib. West. Bot. 15: 59. 1929, apparently based upon plants observed on the desert side of Cajon Pass.

Stem branching above the ground to form a crowded, caespitose clump of four to a hundred or more rosettes, several branches in a single clump often flowering at one time; height of flower stalk 4–13 feet, average 7.5 feet; diameter of flower stalk one meter above the ground, .5–2.75 inches, average 1.3 inches; length of panicle, 1.5–6 feet, average 3.25 feet; diameter of panicle at widest point 4–24 inches, average 12 inches; length of leaves 12–40 inches, average 23 inches.

This subspecies is an associate of the desert woodland, occurring particularly with *Juniperus californica,* usually between 2000 and 4000 feet. It may extend down into the upper limits of the desert shrub formation. It ranges north and west from Arrastre Creek in San Bernardino County along the western border of the Mojave Desert to the region of Walker Pass.

c. Yucca Whipplei subsp. **intermedia** subsp. nov. Type collected at Malibu Lake, Santa Monica Mountains, *A. L. Haines* (deposited in the Herbarium, University of California, Los Angeles).

Caudex a gemmis axillaribus pauciramosus in maturitate solum; scapo florifero saepius solitario altitudine ad 5 m. et ultra, maximam partem circiter 3 m. et diametro in altitudine 1 m. supra humum ad 5 cm., maximam partem circiter 3 cm.; paniculae longitudine ad 2.5 m., maximam partem circiter 1 m. et diametro in latissima parte ad 60 cm., maximam partem circiter 38 cm.; foliorum longitudine ad 1 m. et ultra, maximam partem circiter 60 cm.

Stem branching only by axillary buds after it is well matured; base of stem and roots persistent after flowering to form the subterranean portion of the new plants; only one flower stalk produced in a cluster of rosettes at one time; height of flower stalk 5–15.5 feet, average 9.25 feet; diameter of flower stalk, one meter above the surface of the ground, .5–2 inches, average 1.2 inches; length of panicle .5–7.5 feet, average 3.5 feet; diameter of panicle 6–28 inches, average 15 inches; length of leaves 13–40 inches, average 26 inches.

The type of branching of this subspecies seems to be intermediate between that of subsp. *typica* and subsp. *caespitosa*. It is found throughout the Santa Monica and Santa Susana mountains of Los Angeles and Ventura counties and occurs from sea level up to 2000 feet. It is an associate of the coastal sage and chaparral formations, particularly the chamisal of the latter.

d. Yucca Whipplei subsp. **typica** nom. nov. *Y. Whipplei* Torr. Bot. Mex. Bound. 22. 1859.

Stem simple, solitary, bulbous, dying when fruit has been formed; height of flower stalk 5–13 feet, average 8 feet; diameter of flower stalk, at height of one meter above the ground, 1–4.5 inches, average 2 inches; length of panicle 1.5–7 feet, average 3 feet; diameter of panicle at widest point 6–27 inches, average 13 inches; length of leaves 13–45 inches, average 24 inches.

This subspecies has a stout inflorescence with a thick, short flower stalk bearing a heavy panicle of compact flowers. It occurs from 1000 to 4000 feet and ranges through the Laguna, Balkan, San Jacinto, and Santa Ana mountains. It is associated chiefly with the chaparral formation, particularly the chamisal, but occasionally extends into the coastal sage and desert shrub formations.

e. Yucca Whipplei subsp. **Parishii** comb. nov. *Y. Whipplei* var. *Parishii* Jones, Contrib. West. Bot. 15: 59. 1929; type collected above Cajon Pass near San Bernardino (?). *Y. graminifolia* Wood, Proc. Acad. Philad. 20: 167. 1868, based upon plants observed in "the mountains twelve miles east of Los Angeles," perhaps near Monrovia.

Stem simple, solitary, dying when fruit has been formed; height of flower stalk 7–20.5 feet, average 13 feet; diameter of

flower stalk, at height of one meter above the ground, 1.5–6 inches, average 3.3 inches; length of panicle 3–11.5 feet, average 6.5 feet; diameter of panicle 1–3 feet, average 2 feet; length of leaves 17–46 inches, average 29 inches.

The largest individuals of *Yucca Whipplei* occur in this subspecies. It is distinguishable from the other solitary form of the species by the size of its inflorescence. In all dimensions measured the inflorescence of subsp. *Parishii* is nearly twice as large as the inflorescence of subsp. *typica.* The subspecies is found on the western slopes of the San Bernardino and San Gabriel mountains where it occurs from 1000 to 8000 feet elevation. At lower elevations it occurs with the chaparral and coastal sage formations, at higher elevations it ranges well into the montane forest.

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CERTAIN NORTH AND SOUTH AMERICAN DISTRIBUTIONS IN SCIRPUS

Alan A. Beetle

Recent studies on collections of the cyperaceous genus *Scirpus* L. obtained in South America by the University of California Botanical Expedition to the Andes has revealed a surprisingly high degree of relationship between the species of this genus in the two hemispheres. Although one species is endemic to the California flora a large number of the species is wide ranging making it necessary to study both near and distant floras to discover their true affinities. The genus has many American species. Nothing approaching a general statement may as yet be given for their distribution. Some range widely, whereas others are very narrowly endemic or occupy discontinuous ranges.

The California flora contains sixteen species of *Scirpus* as follows: *S. microcarpus* Presl, *S. Congdoni* Britton, *S. criniger* Gray, *S. paludosus* A. Nels., *S. robustus* Pursh, *S. fluviatilis* (Torr.) Gray, *S. acutus* Muhl., *S. validus* L., *S. californicus* (C. A. Mey.) Steud., *S. Olneyi* Gray, *S. americanus* Pers., *S. nevadensis* Wats., *S. Clementis* Jones, *S. carinatus* Gray, *S. setaceus* L. and *S. cernuus* Vahl. The species known from Argentina were recently well organized by Barros (1). Without following Barros too closely the following entities may be recognized: *S. deserticola* Phil., *S. giganteus* Kunth, *S. paludosus, S. asper* Presl, *S. cubensis* Poepp. & Kunth, *S. californicus, S. validus, S. Olneyi, S. americanus, S. nevadensis, S. atacamensis* (Phil.) Boeckl., *S. rigidus* Boeckl., *S. macrolepis* Boeckl., *S. cernuus* and *S. inundatis* Poir. *Scirpus Clementis, S. criniger* and *S. Congdoni* are endemic in the North American flora while *S. atacamensis, S. rigidus, S. macrolepis, S. giganteus* and *S. deserticola* are

endemic in South America. Nearly fifty per cent of the species comprising these two lists occur both in California and in Argentina. An analysis of the distribution of those species which occur both north and south of the equator should afford some information concerning the interchange of species in general between the hemispheres.

In *Scirpus*, the section *Baeothryon* consists of perennials with spikelets uniformly single, terminal, style 3-fid, and achene smooth, brown. It comprises eight species and one variety, namely *S. hudsonianus* (Michx.) Fern., *S. planifolius* Muhl., *S. Clintonii* Gray, *S. rigidus, S. pumilus* Vahl, *S. Clementis, S. cespitosus* L., *S. cespitosus* var. *callosus* and *S. atacamensis*. Three members of this group have a circumboreal distribution, and the fact that this is an old group is attested by the obvious relationship of two Andean endemics to these northern types. Both *Scirpus cespitosus* var. *callosus* and *S. hudsonianus* are found in North America, Europe and Asia. *Scirpus pumilus* occurs in a few isolated stations in North America, in Europe and has been reported from Tibet (5). The end points of migration down the Rocky Mountains, through the montane regions of Central America and into the Andes, are represented apparently by *S. rigidus* of Peru and Bolivia and *S. atacamensis* of Chile and Argentina.

That *Scirpus planifolius* and *S. Clintonii* are most closely related, within the section *Baeothryon*, to *S. hudsonianus* is shown by their mutual possession of cauline leaves and scabrous triangular culms, and is also strongly indicated by the roughly equiformal areas of their North American distribution. On the same morphological grounds the South American *S. rigidus* is more closely related to these three and less closely allied to its geographical partner *S. atacamensis*. The last species has smooth, terete culms and cauline leaves reduced to mucronate sheaths, conditions which demonstrate its affinity with *S. Clementis* and *S. pumilus*. Acceptance of the latter assumption makes it necessary to postulate one of two possibilities as to their geographic origin: (a) a double migration down the Andes from North America; (b) a continuous range from North to South America for some prototype which has diverged along parallel lines of evolution subsequent to the geographic isolation of some of its parts. In either case the history of the plants undoubtedly dates back to the Pliocene when, coincident with the earliest invasion of South America by holarctic fauna (6, 9), one or more of the species may be assumed to have had its widest distribution. Fernald (4) has pointed out that the present fragmentary distribution of *Scirpus pumilus* is probably a direct result of Pleistocene glaciation.

Various species in other sections of the genus show an interruption of their ranges in the tropics. *Scirpus nevadensis* is found to be an uncommon plant in the western United States and Canada occupying strongly saline soils over a wide area. It is rare in

Argentina where it also appears in strongly saline habitats over a wide area. The species is, however, unreported between northern Argentina and Mono County, California. It may have been a coastal, salt marsh type or perhaps was formerly tolerant of fresh or only slightly saline water. Analogies exist today in *S. paludosus, S. americanus,* and *S. acutus* which grow on the sea margins, on the borders of inland fresh-running streams and lakes and in the saline soils of the Great Basin. The uplift of the Rocky Mountains and the Sierra Nevada initiated the changes which resulted in the disappearance of some of the inland lakes and increased the salinity of others. Gradually, in accompaniment with this change, *S. nevadensis* may have developed an adaptive tolerance toward aridity. The southern members of the species may have passed through a similar history but the members between were faced with a different problem; either they disappeared or gave rise to such closely related species as *S. Olneyi* and *S. americanus.*

Scirpus paludosus, S. validus and *S. Olneyi* are similar to *S. nevadensis* in the interruption of their ranges by a broad belt of the tropics including at least Central America and South America north of the Amazon but they differ in being much more abundant in North America than in South America. There are several possible explanations to account for the existence of this broad hiatus in distribution which is certainly not a reflection of incomplete collections: (a) the species may be spreading from the northern to the southern hemisphere and have not yet had time to occupy all of their potential area; (b) these species may, perhaps, have been more abundant in the past but are becoming depleted in the southern hemisphere due to the impact of changing conditions; (c) greater competition in the southern hemisphere flora may possibly have hindered the spread of these species since they first appeared there; (d) since they are not especially tolerant of tropical conditions a migration through that area may have been accomplished by a few of the more tolerant biotypes. *Scirpus paludosus* and *S. validus* are evidently plastic species to which the first alternative may be applicable but *S. Olneyi* appears to be a more rigid type and the other alternatives may have to be called into account.

Scirpus cubensis which is common in Chile is reported also from Panama by Standley (10). *Scirpus inundatus,* known from as far south in Chile as the Valdivian Lakes region is also reported from Costa Rica by Clarke (3, p. 460). *Scirpus cernuus,* a ubiquitous species with a world wide distribution in temperate regions avoids the tropics.

Scirpus californicus and *S. americanus* also have a disrupted range but differ from the preceding species in being widespread and fairly common in both hemispheres. They come nearest to bridging the tropical barrier. *Scirpus californicus* is known from the San Francisco Bay region south to Guatemala, and from Co-

lombia, Ecuador and Brazil to middle latitudes in South America. To this is added *S. californicus* var. tereticulmis (Steud.) comb. nov. (*S. tereticulmis* Steud. Syn. Pl. Cyp. 85. 1855) extending the total range from central South America to the Straits of Magellan. A more uniform climate would undoubtedly amplify this broad latitudinal range. There is geological evidence (2) that uniform, moist climates existed at several different periods of Tertiary time.

Scirpus americanus, finally, is known from Nova Scotia and Alberta south to Mexico and from Peru and Brazil to Patagonia. Morphologically similar plants grow indiscriminately in fresh and strongly saline waters. The extreme variability in this species is suggested by the number of taxonomic variations which have been recognized in it. Such a high degree of polymorphy would seem to mark it as a comparatively young species which is reaching the peak of its distribution at the present time.

There has now been presented a graded series of geographical distributions from the endemics of section *Baeothryon* on the one extreme to the ubiquitous *Scirpus americanus* on the other. The most widely ranging species in the series are those with the greatest variation. This fact suggests that at the time when its number of biotypes and range of tolerance is greatest it is possible for a species to cross well-marked climatic barriers. Probably *S. Clementis* and *S. atacamensis* together represent an old species which, with advancing age, depauperization of biotypes and wide separation, became modified in descent to slightly different end points. Since they occupy areas isolated from other members of their section this assumption seems more reasonable than to suppose that they never had a sufficient wealth of biotypes to create an overlapping of their now discrete ranges; that is, chance dispersal or fortuitous origin depend on close relatives living in nearly adjacent territories. The species whose distributional pattern is intermediate in character between those of *S. Clementis* and *S. americanus* may be classed logically as intermediate in age if they no longer occupy their maximum range, or as young species if they have yet to reach a maximum range.

The methods of dispersal of *Scirpus* are not yet completely analyzed. Most species are stoloniferous perennials which migrate easily either up or down stream along muddy river banks. Birds eat the fruits and may carry them for short distances, that is, from one drainage area to another, in their digestive tracts, or in mud adhering to their feet. Undoubtedly important also is the buoyant nature of the fruits, although this is an extremely variable factor. Achenes of *S. americanus* are considered to be non-buoyant but are abundant in lake drift (7) while those of *S. maritimus* L. may float for a month (8, p. 239), not sinking until the pericarp decays. Finally the element of chance dispersal undoubtedly plays a considerable role over a long period of time. The prevalent uniformity of the aquatic habitat must be largely responsible for the high degree of relationship over wide areas.

A conclusion similar to that reached by Matthew (6) in connection with a study of the evolution of land vertebrates may be drawn. It would seem to be unnecessary to postulate any profound change in the existing distribution of land masses to account for the present distribution of *Scirpus* between the two hemispheres. To assume change in climate is probably unnecessary since species are apparently being interchanged between North and South America at the present time, but a more uniform climate would facilitate this process. Such changes as did occur in the past certainly have had their effect on the history of the species concerned, but, apparently, any theory involving cataclysmic phenomena is not essential to account for the migrations of North and South American species of this genus.

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March, 1940.

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THE PROBLEM OF LIFE ZONES ON MOUNT SHASTA, CALIFORNIA

William Bridge Cooke

In 1898 a party led by Dr. C. Hart Merriam made a biological survey of Mount Shasta. In the report (6) published in 1899 Dr. Merriam defined the several life zones he found on the mountain on the basis of his earlier discussion of North American life and crop zones (5). The writer, after four years of study, has come to the conclusion that two of the three zones must be revised or clarified (or, as to one of them, completely eliminated) in order that the casual visitor and future worker may be less confused as to the boundaries of the upper zones. The present paper is an

attempt to point out some of the problems encountered and the conclusions resulting from a study of these problems.

The Upper Sonoran zone (in Merriam's terminology) occurs within sight of the mountain in Shasta Valley to the north, in Sacramento Valley to the south, and in the valleys of the Great Basin areas to the east, for example, the areas found in the vicinity of the Modoc Lava Beds National Monument (1). On Mount Shasta this zone does not occur above 4000 feet, the contour line which has been chosen as the lower limit of the area covered by this study.

The Transition zone is clearly differentiated on Mount Shasta. Where the base of the mountain extends down to 4000 feet this zone can be divided into two minor belts. The lower of these may be called the Chaparral Belt. The term refers here to a Transition zone chaparral, a broader interpretation than that of Cooper (2). Wherever the Transition zone forest has been disturbed on the mountain a dense growth of chaparral has taken its place and to a certain extent has invaded the remaining forested portions. Before the Shasta National Forest was established, great areas of timber were logged. Fire contributed to the further destruction of whatever forest might have been left so that the former forest composition must be reconstructed by study of the accounts of early travelers and from isolated trees and small groves throughout the area. The zone is dominated by *Arctostaphylos patula* and *Ceanothus velutinus*. Additional shrubs include: *Ceanothus cordulatus, C. divaricatus, C. prostratus, Castanopsis sempervirens, C. chrysophylla, Purshia tridentata, Pachystima myrsinites* and others listed in Table 1.

Above the chaparral belt there is a narrow belt of forest, typical of the normal Sierran Transition zone except that on the northeast quarter of the mountain there occurs a large stand of *Pinus contorta* var. *Murrayana* which almost completely replaces the normal forest association. The normal forest, except where it is invaded by the chaparral, includes the following coniferous species: *Pinus ponderosa, P. Lambertiana, P. monticola, P. attenuata, P. contorta* var. *Murrayana, Abies concolor, A. magnifica* var. *shastensis, Libocedrus decurrens* and *Pseudotsuga taxifolia.* Various species of deciduous trees and shrubs which form lower stories in this forest are listed in Table 1.

Above the Transition zone forest is the Canadian zone as interpreted by Merriam. Except on the northeast side it is almost wholly composed of *Abies magnifica* var. *shastensis* which covers an altitudinal belt of from 500 to 1500 feet around the mountain. At the head of Panther Creek, and between the east side of Gray Butte and the west side of Mud Creek Canyon, and at one or two other small isolated stations, *Tsuga Mertensiana* enters this forest. Locally there may be colonies of from a few hemlocks in the fir forest to a few firs in the hemlock forest. In the vicinity of upper

TABLE 1

Species of woody plants occurring in the Transition Chaparral (Ch), Transition Forest (T), Canadian (Ca) and Hudsonian (H) zones on Mount Shasta, compared with the Zone Indicators of Hall and Grinnell (3) for Upper Sonoran (US), Transition (T), Canadian (Ca) and Hudsonian (H) zones.

Species	Position on Shasta	Zone Indicator
Abies concolor	ChTCa	T
Abies magnifica var. shastensis	TCaH	Ca
Acer glabrum	TCa	Ca
Alnus viridis var. sinuata	CaH	
Amelanchier alnifolia	ChT	
Arctostaphylos nevadensis	TCaH	Ca
Arctostaphylos patula	ChTCa	T
Castanopsis chrysophylla	ChT	T
Castanopsis sempervirens	ChTCaH	Ca
Ceanothus cordulatus	Ch	
Ceanothus divaricatus	Ch	US
Ceanothus prostratus	ChT	T
Ceanothus velutinus	ChTCa	T
Cercocarpus ledifolius	CaH	
Chamaebatiaria millefolium	Ca	
Chrysothamnus Bloomeri var. angustatus	ChTCaH	
Chrysothamnus nauseosus var. occidentalis	Ch	
Cornus californica	T	
Cornus Nuttallii	Ch	T
Juniperus communis var. montana	H	
Kalmia polifolia	CaH	H
Libocedrus decurrens	ChT	T
Lutkea pectinata	CaH	
Pachystima myrsinites	Ch	
Phyllodoce empetriformis	CaH	
Pinus albicaulis	CaH	H
Pinus attenuata	ChT	US
Pinus contorta var. Murrayana	TCa	Ca
Pinus Lambertiana	ChT	T
Pinus monticola	TCa	Ca
Pinus ponderosa	ChT	T
Pinus ponderosa var. Jeffreyi	TCa	Ca
Populus tremuloides	TH	Ca
Populus trichocarpa	T	
Prunus demisa	Ch	T
Prunus emarginata	ChTCa	
Prunus subcordata	Ch	
Pseudotsuga taxifolia	ChT	T
Purshia tridentata	ChT	US
Ribes cereum	ChTCaH	
Ribes divaricatum	Ch	
Ribes nevadense	T	
Ribes Roezlii	ChTCa	
Ribes viscosissimum	ChTCa	
Salix Scouleriana	ChTCa	
Sambucus caerulea	ChT	
Sambucus racemosa	Ca	
Tsuga Mertensiana	CaH	H
Vaccinium caespitosum	Ca	
Vaccinium occidentale	TCa	Ca

TABLE 2

Species of herbs occurring in the Canadian (Ca), Hudsonian (H), and Subalpine (A) zones on Mount Shasta compared with zonal distribution of previous records (Arctic-Alpine, AA), and with the Hall and Grinnell Indicator lists.

Species	Position on Shasta	Reported position	Indicator of Zone
Achillea lanulosa var. alpicola	H	AA	
Carex Breweri	CaHA	AA	AA
Carex phaeocephala	A		
Dicentra uniflora	CaH	AA	
Draba Breweri	HA	AA	AA
Erigeron compositus var. trifidus	HA	AA	H
Hulsea nana	HA	AA	AA
Juncus Parryi	CaHA	AA	
Lewisia pygmaea	H		AA
Lewisia triphylla	H	AA	Ca
Oxyria digyna	CaHA	AA	AA
Penstemon Menziesii var. Davidsonii	CaHA	HAA	AA
Phacelia frigida	HA	AA	
Poa Pringlei	A		
Polemonium shastense	HA	AA	
Polygonum minimum	H		
Polygonum Parryi	H		
Polygonum shastense	CaHA	HA	H
Potentilla flabellifolia	H	H	Ca
Potentilla Sibbaldii	H	H	AA
Saxifraga Tolmiei	HA	AA	AA
Silene Watsonii	HA	AA	

Squaw Valley Creek hemlock makes up nearly seventy-five per cent of the forest cover. In the middle and lower portions of the zone a few individuals of *Pinus monticola* may be scattered among the firs. However, along the west bank of Mud Creek Canyon this species is represented by scattered individuals from the upper limit of erect firs to the middle of the Transition zone forest. One of the interesting features of this zone is the forest on the northeast quarter where the Canadian zone may not exist at all, or where it may be considered as replacing the Transition zone forest. Here species of the Transition zone, including *Pinus ponderosa* (possibly the variety *Jeffreyi*) and *Abies concolor* mingle in a mixed forest with (a) species from the Hudsonian zone, including *Pinus albicaulis* and *Juniperus communis* var. *montana;* (b) species from the Canadian zone, including *Abies magnifica* var. *shastensis* and *Pinus monticola;* and (c) the anomalous species (at least on Mount Shasta) *Pinus contorta* var. *Murrayana, Castanopsis sempervirens* and *Ribes cereum.*

At the borders of the Canadian zone are broad areas transitional to the Hudsonian zone above and the Transition zone below. The belt on the lower side includes *Abies concolor, A. magnifica* var. *shastensis* and *Pinus ponderosa* var. *Jeffreyi.* In a swamp at Wagon Camp *Vaccinium occidentale* is dominant. The belt on the upper

side includes semierect or dwarfed specimens of ***Pinus albicaulis, Abies magnifica*** var. ***shastensis*** and ***Tsuga Mertensiana.*** These transitional belts could be labeled with the combined names of their commoner species: "Mixed Fir-Jeffrey Pine belt" and "Pine-Fir-Hemlock belt." In addition to the coniferous trees which have been mentioned as components of the Canadian zone, a number of broadleaf trees and shrubs occur in the area. In the dry forests are ***Ribes cereum, R. viscosissimum, Cercocarpus ledifolius*** and ***Populus tremuloides;*** while in the meadows and spring areas occur ***Phyllodoce empetriformis, Kalmia polifolia, Lutkea pectinata*** and ***Alnus viridis*** var. ***sinuata*** in addition to others listed in Table 1. Arms of the previously mentioned chaparral extend into this zone.

It is above the Canadian zone that difficulties are encountered. These difficulties lie in the interpretation of timberline, in the distinction between the Canadian and Hudsonian zones and in the presence or absence of an Arctic-Alpine zone.

Merriam considered an Arctic-Alpine zone present on the mountain. He thought that timberline coincided with the highest limits of ***Pinus albicaulis,*** even though at its highest limits all individuals are reduced to mats of from a few inches to a foot or more in height. With this interpretation, timberline is the upper limit of the Hudsonian zone, which is almost exclusively made up of, and is characterized by, ***Pinus albicaulis.*** Timberline, then, according to Merriam, divides the Arctic-Alpine from the Hudsonian zone. Thus timberline extends up most ridges on the mountain to heights of from 9000 to 9500 feet, with occasional arms up to 10,000 feet. The basins formed by Post-Pleistocene glacial cirques, and by moraine materials at about 8000 to 8500 feet would have a much lower timberline, perhaps between 8000 and 8500 feet, depending on the more or less strict application of the term to isolated stands of pines on the faces of minor ridges (with barren gulleys between and below them) and to the presence or absence of trees of any height on the flats below these ridges. The Arctic-Alpine zone, then, would include the areas on ridges on which a fair stand of dwarf pine occurs and which lie in the shade most of the day and thus are considerably cooler in climate. These cooler ridge slopes are on the south and east sides of the ridges and hold snow banks longer, at a lower elevation, than other more exposed areas. In one place, at least, on the north side of Red Butte, there is a small timberline area with a growth of plants above it. This small community was included by Merriam in the Arctic-Alpine zone because of its more severe climate as indicated by an association of plants which includes: ***Polemonium shastense, Silene Watsonii, Oxyria digyna, Saxifraga Tolmiei*** and others. However, it was admitted that on top of the Butte, several hundred feet above this colony, there is a fairly large stand of Hudsonian zone timber. A number of similar "Arctic-Alpine" associations occur below timberline as conceived

by Merriam, some of which grow in climatically restricted areas such as this, while others occur in apparently normal Hudsonian zone climate.

There are other conceptions of what constitutes timberline. We are referring here, of course, to alpine timberline rather than to sea-level poleward timberline, or to those desert or grassland associations on the borders of which tree species drop out in transition belts. United States forest rangers of the Shasta National Forest consider timberline as the upper altitudinal limit of upright tree growth. This is an economic interpretation of the word. In this sense the line or belt between the Canadian and Hudsonian zones is timberline. According to Hopkins (4, 7): "Climatic timberline may be defined as the poleward sea-level or alpine altitude limit of upright growth of tree species, under otherwise favorable conditions, as distinguished from dwarf or prostrate forms of the same species, as controlled by the climatic elements of temperature, wind, snow, ice, etc.; and also as distinguished from limits of tree growth due to the absence of suitable soil, moisture, or the presence of local glaciers." In the sense of Hopkins, then, Merriam's Shasta Hudsonian zone would occur above climatic timberline (which coincides with the economic timberline of the forest ranger).

Proceeding to the problem of the Merriam Arctic-Alpine zone on Mount Shasta, it should be noted that the term "Arctic-Alpine" is misleading. Conditions of growth in the arctic circle are different from those in an alpine habitat where the air pressure is lower, the proportion of daylight nearly the same as that normal to the latitude under consideration and temperature change during the growing season more frequent. Since these factors affect food production and other physiological processes of the vegetation the Arctic zone should be differentiated from the Alpine. On Mount Shasta, then, the vegetation may be considered alpine rather than arctic and according to either Merriam or Hopkins the zone would occur above the limits of tree growth. This zone, therefore, if recognized on Mount Shasta, is characterized purely by herbaceous plants.

The Alpine zone may be interpreted in terms of associations or an association of plants, in which sense Merriam occasionally used the term in discussing the flora of the mountain. On Mount Shasta a number of species reputedly occur (6) above tree-line. These include: *Polemonium shastense, Oxyria digyna, Phacelia frigida, Silene Watsonii, Draba Breweri, Carex Breweri, Juncus Parryi, Dicentra uniflora, Saxifraga Tolmiei* and others. However, all these species have been discovered below the upper limits of tree growth in various habitats such as draws, flats, gulleys and ridges which occur in Merriam's Hudsonian zone; all these species have been observed in association with *Pinus albicaulis*. The only species yet known which occur above timberline as delimited by Merriam and

not also below it are *Carex phaeocephala* and *Poa Pringlei* both of which were collected in 1939 along the Summit Trail in an area which Merriam would have called truly alpine since it lies at between 9000 and 10,000 feet, in the cirque in question fully 500 to 1000 feet above the highest limits of his interpretation of timberline. Merriam had no temperature records upon which to base his Shasta Alpine zone. He therefore based it upon the association of plants found in an area which should have certain theoretical temperatures. But is this association truly alpine when all but two of its constituents (these two unreported until recently) are found in the Hudsonian zone?

Hopkins defines the bioclimatic zones in three major zones and a number of minor zones. The three major zones include: I. "North and south, polar or arctic and alpine, humid or arid major regions of the Frigid Zone." II. "North and South, temperate or intermediate latitudes or altitudes, major arid and humid regions of the Temperate Zone." III. "Tropical and equatorial low and high land, humid and arid major regions of the tropical zone." Four groups of minor zones, of which group 4 is warmest, are described under Major zone I. Upper minor zone 4 is defined as "Arctic and alpine above and below perpetual ice and snow, lower transition or snow line zone." Under Major zone II, Hopkins describes seven groups of minor zones of which group "1" pertains to the present problem. Under "Upper minor zone 1" the following definition is listed: "High latitudes and altitudes, subarctic and alpine regions and areas above climatic timberline or its equivalent, 'timberline zone.' " "Lower minor zone 1" is "timberline."

Mount Shasta has no permanent snow line. The five glaciers which are still active are confined to areas above 10,000 feet and apparently have no immediate effect on the surrounding vegetation. In their vicinity the soil is too poor and the drainage too complete for an association of plants to survive even though no glacier occurred. The permanent snow fields on the mountain are small and scattered and have little effect on the minimal vegetation in their vicinity largely because they are above the areas where plant life, except lichens and algae, survives even sparsely.

From these considerations, an Alpine zone on Mount Shasta is not to be expected. Certainly if permanent snow lines do not exist on the mountain, by definition, Major zone I is absent. The next zone is Major zone II, Upper minor 1. This is subalpine, and from areas of greater distribution of plants, might even be considered upper Hudsonian. However, the finer threads cannot be split until more definite statistics are available for the climate of the mountain, especially in its upper regions, throughout the year.

Foster, Warren County, Ohio,
December, 1939.

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A NEW SPECIES OF LOTUS FROM THE MOUNT HAMILTON RANGE, CALIFORNIA

Helen K. Sharsmith

Lotus rubriflorus sp. nov. Herba annua albosericea, pilis longis; caules 1–5 aliquando decumbentes, 3–10 cm. longi; folia 10–16 mm. longa exstipulata, 4-foliolata imparipinnata, rachibus complanatis, foliolis lanceolatis acutis, 2–11 mm. longis; flores solitarii axillares subsessiles, 6–7 mm. longi; calyx dense pilosus lobis linearibus acuminatis, 4–5 mm. longis, corollam aequantibus; petala rubra in aetate caerulescentia; legumina pilosa, oblonga dehiscentia, 8–9 mm. longa.

Slender annual; stems 1–5 (mostly 2–4) from base, 3–10 (mostly 4–8) cm. long, usually somewhat decumbent; herbage pilose throughout with long, white, silky, somewhat appressed or spreading hairs; leaves 10–16 mm. long, exstipulate, imparipinnate; rachis flattened, about 1 mm. broad; leaflets 4, two appearing terminal, the remaining two on one side of the rachis, 2–11 mm. long, subsessile, lanceolate, acute, terminal leaflets often slightly falcate; flowers 6–7 mm. long, solitary, axillary, subsessile, usually bracteate; calyx 6–7 mm. long, densely pilose; tube 1.5–2 mm. long; lobes linear, acuminate, 4–5 mm. long, equalling corolla; petals glabrous, clear bright pinkish red (aster purple[1]), fading bluish, claws white, banner 5 mm. long; wings shorter than or about equalling keel, posterior dorsal lobes large and very narrowly margined with white; keel 5 mm. long, apex somewhat pointed, body very narrowly margined with white dorsally and posteriorly; ovary densely pilose, dorsal margin straight, ventral margin curved; style pilose below, glabrous above, curved near base; legumes pilose, 8–9 mm. long, 2.5 mm. wide, oblong, stramineous; seeds 2–4, 2 mm. long, 2 mm. wide, irregularly lens

[1] Ridgway, R. Color standards and color nomenclature, plate 12. 1912.

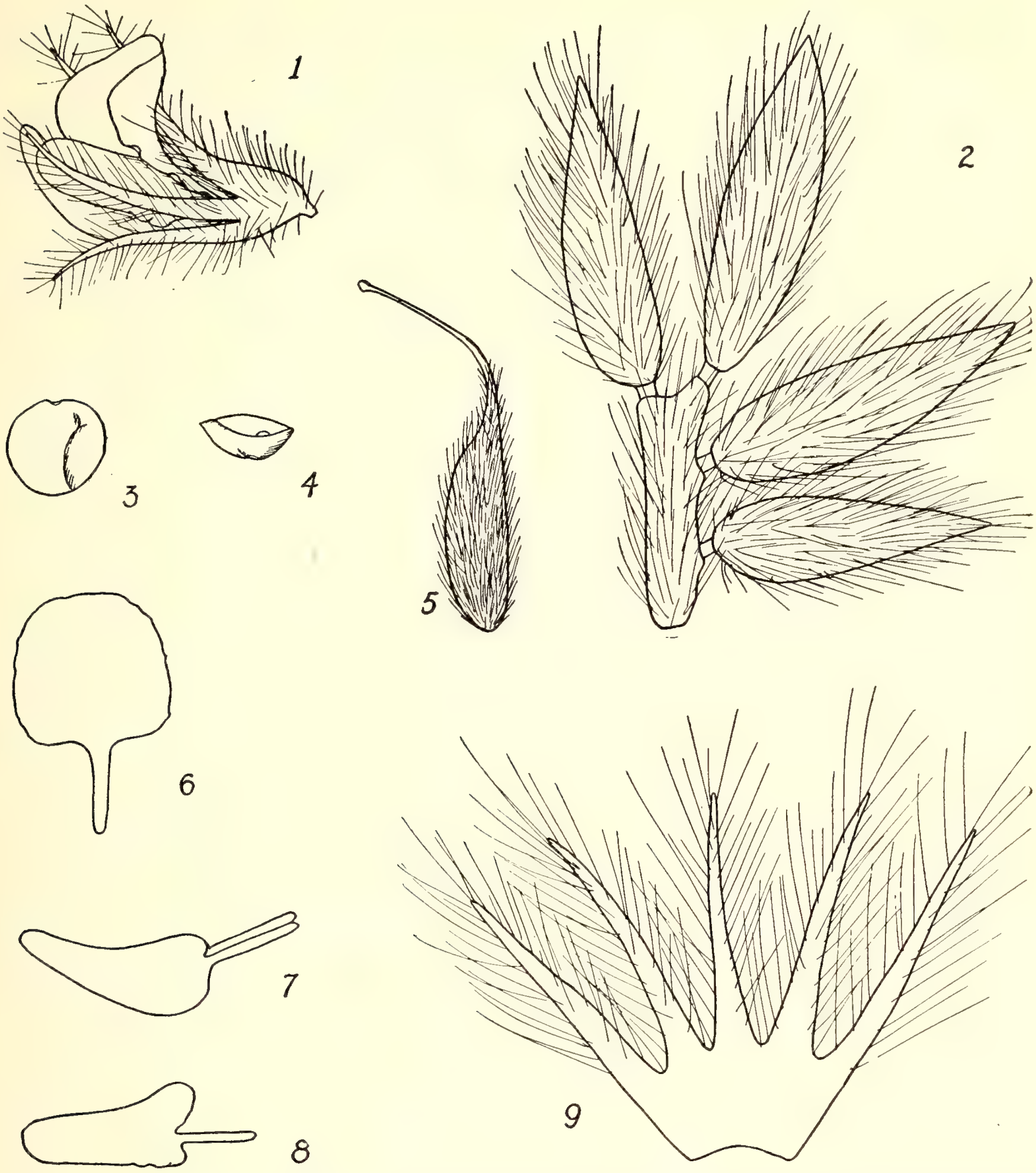

FIG. 1. *Lotus rubriflorus* H. K. Sharsmith: *1,* flower; *2,* leaf; *3,* seed, lateral view; *4,* seed, anterior view showing hilum; *5,* ovary; *6,* banner; *7,* keel; *8,* wing; *9,* interior of calyx. All ×5.

shaped, angled, notched at hilum, olive green to light brown, usually mottled with deeper brown, the surface often with a bronze sheen.

Type. Rolling hills at north end of Adobe Valley, Stanislaus County, Mount Hamilton Range, California, altitude 1600 feet, April 22, 1936, *A. M. Carter & H. K. Sharsmith 3544,* in flower (Herb. Univ. Calif. No. 605765; isotypes, Gray Herb., U. S. Nat. Herb., Mo. Bot. Gard., Stanford, Kew). Topotype. June 5, 1938, *A. M. Carter & J. L. Morrison 1403,* in fruit (Herb. Univ. Calif.; duplicate topotypes deposited with isotypes).

Lotus rubriflorus has been found only at the type locality, but within the one known colony the plants are abundant. Collections made two years apart suggest that the species is not merely transient at this locality. It inhabits sparse grassland in an open stand of *Quercus Douglasii,* growing in association with the common vernal annuals of the region, such as *Lotus subpinnatus, L. humistratus, Orthocarpus attenuatus, Microseris linearifolia, M. sylvatica, Pentachaeta exilis, Plagiobothrys canescens.*

On the basis of the pinnate, short, exstipulate leaves, the small, solitary flowers, and the straight, beakless, dehiscent legumes, *Lotus rubriflorus* belongs to the subgenus *Acmispon* (Raf.) Ottley (Univ. Calif. Publ. Bot. 10: 197. 1923). Within this subgenus, *L. rubriflorus* is most closely associated with *L. denticulatus* Greene, *L. subpinnatus* Lag., and *L. humistratus* Greene, these species all having dilated leaf rachises, few, inequilateral leaflets, subsessile flowers, and flattened, angled seeds.

Although growing in association with *Lotus humistratus* and *L. subpinnatus, L. rubriflorus* is a very distinct, easily recognized species. It most closely resembles *L. humistratus* in pubescence, length of calyx lobes, and shape and size of legumes, but is more pilose, and the calyx lobes are longer. It differs strikingly from *L. humistratus,* as well as from *L. denticulatus* and *L. subpinnatus,* in the lanceolate leaflets. Furthermore, the flower color of *Lotus rubriflorus* is exceptional; in North American representatives of the genus the corolla is characteristically whitish or yellow, although often veined, streaked or suffused with red, pink, or purple, or may fade red. In *L. rubriflorus* the corolla is a uniform red. The following key brings out these distinguishing features and separates *L. rubriflorus* from those species to which it is most nearly related:

Leaflets obovate, often obtuse; flowers cream color to yellow,
  tinged with or fading red or purple .... *L. denticulatus*
L. humistratus
L. subpinnatus

Leaflets lanceolate, acute; flowers bright pinkish red, fading
  bluish .... *L. rubriflorus*

State College of Washington,
Pullman, Washington,
February, 1939.

REVIEWS

A Monograph of the Genus Calochortus. By Marion Ownbey. Annals of the Missouri Botanical Garden. Volume XXVII. Pp. 371–560. St. Louis, December 10, 1940.

The genus *Calochortus,* ranging from Nebraska to the Pacific and from Guatemala to British Columbia, is treated by Dr. Ownbey in three sections, *Eucalochortus, Mariposa* and *Cyclobothra.*

The sections are divided into twelve subsections under which are arranged the fifty-seven species and thirteen varieties.

Dr. Ownbey's approach to the problems in *Calochortus* from the viewpoint of herbarium study, extensive field work, garden cultures and cytological investigation gives his work a definitiveness possessed by too few monographs. While some botanists may feel that he has admitted to specific rank several entities that might better have received subspecific status, on the whole his decisions seem to be based on a firm foundation of evidence both from comparative morphology and from geographic distribution.

The publication of seven new species and ten new varieties should arouse keen interest in the further study of local areas. Of great significance in this connection is the speciation that has taken place in the Siskiyou Mountains of southern Oregon and northern California where four local, very distinct, rarely collected species are found. This area should continue to be a fertile collecting ground.

Because of the cytogenetic approach and the fact that Dr. Ownbey is now working in the west where garden cultures and field studies may be carried on we await with great interest any additional developments in the phylogenetic analysis of this genus.—John L. Morrison, Department of Botany, University of California, Berkeley.

The Flora of Whatcom County, State of Washington. By W. C. Muenscher. Pp. 1–134, with 10 figures and 1 table. William A. Church Company, Ithaca, New York, 1941. Published by the author.

A county flora is so rarely prepared for a portion of any of the western states that the appearance of a less excellent volume than the present one evokes especial comment.

The twenty-three hundred square miles comprising Whatcom County occupy the northernmost county of the Pacific Coast and extend in altitude from near sea-level on Puget Sound to 10,750 feet at the summit of Mount Baker, one of the principal peaks of the Cascade Range. With the coastal hills in the Transition life zone, and timberline on Mount Baker at only 6000 feet, all of the boreal zones are thus represented in a relatively small altitudinal range as well as in a small area. With these facts in mind, one will be less astonished at the inclusion of 1042 species and varieties. The author contributed an earlier catalogue of the same area to "Muhlenbergia" in 1914, and has noted additions to this original list, chiefly in "Torreya" and Madroño, during the subsequent years. A substantial portion of the list is owing to the writer's predilection for aquatic and introduced plants, both of which are too likely to be overlooked by collectors. Although the plant records of the present book are based primarily upon Dr. Muenscher's own collections, the first set of which is preserved

in the herbarium of Cornell University, he has consulted the collections of others as well.

The diversity of topics treated in the introduction reflects the author's wide botanical interests. An interesting feature is the presentation of lists of those species characteristic of such distinctive habitats as alpine meadows, salt marshes, gravelly prairies and coastal cliffs. A brief account of the zonation of vegetation is handsomely illustrated by carefully selected photographs. A conveniently classified list is offered of plants deemed suitable for cultivation.

In the annotated catalogue, which constitutes two-thirds of the book, the genera and species are alphabetically arranged under the systematically ordered families. Neither keys nor descriptions are provided. The abundance and characteristic habitats of each species are described and authenticating specimens are cited for each. It thus becomes possible for the perennially skeptical specialist to check the identity of every item attributed to the group with which he is especially concerned.

The taxonomic treatment is, on the whole, conservative, and pretty thoroughly up to date. The current bitter controversy between the advocates of "subspecies" and the proponents of "varieties" is met by calling all subspecific entities, except forms, "varieties," and retaining the original authors of the trinomials, regardless of whether they designated the subspecific or varietal category. This has the curious effect of attributing "varieties" to such authors as Hall and Clements, Piper, and Pennell, which will probably bring down the wrath of both factions. There is also some inconsistency in the capitalization of specific names, which will doubtless provide ammunition for the arsenal of those advocating uniform decapitalization.

This flora is, happily, much more than an unusually complete and attractively prepared catalogue of the plants of one western county. Because of the wide range of habitats and altitudes contained in this one political division, it is essentially a catalogue of the flora of western Washington. It is to be hoped that the completion of this very satisfactory study will encourage the preparation of other much needed local floras throughout the west.—L. Constance, Department of Botany, University of California, Berkeley.

Experimental Studies on the Nature of Species. I. Effect of Varied Environments on Western North American Plants. By Jens Clausen, David D. Keck and William M. Hiesey. Carnegie Institution of Washington publication 520. Pp. vii + 452. 1940. Paper, $3.50. Bound, $4.50.

This stimulating volume represents the application of methods in experimental taxonomy to an understanding of the involved intrarelationship of several complicated groups of species. The application of the method to specific problems serves in this case

as a vehicle to outline the method of research. The groups of plants selected are *Potentilla glandulosa* and its allies, *P. gracilis* and its allies, *P. Drummondii* and *P. Breweri, Horkelia fusca* and *H. californica,* the genus *Zauschneria,* certain groups of *Penstemon,* the *Achillea millefolium* complex, the *Artemisia vulgaris* complex and a large number of well selected minor problems in groups ranging from the Gramineae through the Compositae. The volume is prefaced with a short historical sketch of the research project; a brief tribute is paid to the late Dr. Harvey Monroe Hall under whose able direction the work was begun. It is a point of major interest that the authorship should include a cytogeneticist, a taxonomist and a plant physiologist.

In establishing the experimental method the problem was approached from many points of view and several methods were tried and discarded before the final procedure was adopted. The plant materials selected were those that could be used as clone transplants. A clone is defined by the authors as "all asexual propagules derived from one individual." These were subjected to varied environments: cytogenetic studies were made: a revised taxonomic analysis was presented based upon the results of these experiments. The terminology follows closely that of Turesson.

For purposes of review the treatment of *Potentilla glandulosa* and its allies (section *Drymocallis*) affords an illustration of the mode of attack. This group had received varied and haphazard treatment at the hands of the old school taxonomists. It was selected because of its widespread vertical and horizontal distribution, its great variability and its ready adaptability to garden manipulation. Specifically, California ecotypes from the following stations were used: Coast Range; Sierra Nevada, foothill, mid-altitude meadow, subalpine and alpine. These differed morphologically and showed some variability in seasonal rhythm. They possessed the uniform chromosome number $n = 7$. There are no genetic barriers between them. Clone transplants of each ecotype were established in California at three stations: a coastal station at Stanford University, a middle station at Mather, and a timberline station near Saddlebag Lake. The latter stations are in the Sierra Nevada.

Observations were made to determine constant characters, seasonal differences, effects of light and moisture differences and effects of altitude. The reversibility of environmental modifications was established for some ecotypes by taking clone members of changed individuals back to the original environment.

In general it was found that each ecotype retained a certain individuality in all three stations. This was regarded as being due to the sum total of hereditary characters. Each responded to the different environments in a very characteristic way; these changes (modifications) were superimposed over the hereditary characters. While morphological change was slight the annual cycle or response to the rhythm of seasonal events was profoundly

changed. In some cases, however, this change was not sufficient to insure survival.

Cytogenetic studies had as their objective "to interpret the taxonomic status of the various forms by testing the degrees of genetic relationship, to explore their evolutionary background by analysis of gene or chromosome differences and to determine their utility for various ecogenetic investigations." In determining whether they were dealing with ecospecies or ecotypes the following criteria were adopted: Crosses between ecotypes would produce a second generation in which the parental genes would be recombined in all proportions without resulting in constitutional weakness of the offspring. In crosses between ecospecies the genic recombinations would produce many constitutionally weak offspring which would barely survive under favorable conditions. Thus there would be constitutional weakness plus environmental unfitness in the offspring of the cross between ecospecies. It has been established in such species of the section *Drymocallis* as have been studied that the "diversity distinguishing ecotypes and ecospecies has been produced by a simple genic differentiation." Genic incompatability, they report, is slight. It was found that hybrids between the ecotypes were easily produced and fully fertile and the conclusion was drawn that they were true ecotypes of a large and variable ecospecies. The authors conclude that "*Potentilla glandulosa* presents a picture of evolutionary differentiation into ecologic units, the ecotypes, which are not separated from each other by breeding barriers. The ecotypes fit their specific climates and differ by many characters, both physical and morphological. Each of these characters appears to be determined by a series of genes, and is often genetically linked with others. The many differences in genes with minute effect furnish the basis for the multiplicity of intergrading forms observed in nature, and the linkage relations suggest a reason for the limited number of taxonomic units that can be recognized in spite of recombinations and lack of internal barriers."

As a result of many such experimental studies certain general conclusions are drawn relative to the problems of regional differentiation. These are discussed in the form of eleven laws governing the nature of modification, its genetic limitations and environmental control and the bearing of modification and genetic differentiation on the development of regional races. Regional races are interpreted as ecotypes or ecospecies which have developed in harmony with their environment through genic differentiation of one sort or another and are under the control of natural selection. Regional differentiation implies discrimination between unlike environments. These units, the ecotype and the ecospecies, are regarded as the natural units of ecological and evolutionary behavior. These conclusions are in close agreement with Turesson's statements regarding the genotypical response of the plant species to its habitat.

The volume is replete with tables and graphs giving comparative measurements of the plant and its parts as it developed in the different environments. Photographic illustrations of plants and of specimen vouchers provide convincing demonstration of the results obtained.

This work at once becomes a classic in the field of experimental taxonomy. Regardless of agreement or disagreement as to precise limitation in the definition of species the problem of the pattern of relationship within closely allied groups is clearly set forth by such methods as these. Obviously it will be impossible to subject all plant groups to similar experimentation. It is hoped, however, that enough such work can be done to complete the picture of the nature of relationships in plants so that a pattern can be established into which such plants as are not adaptable to this mode of treatment can be placed.—Herbert L. Mason.

NOTES AND NEWS

The following monographic studies and other important taxonomic articles have appeared recently: "preliminary list of desmids of the Pacific Northwest with descriptions of some new forms," by Gordon D. Alcorn (Occas. Papers, Dept. Biol. Coll. Puget Sound, no. 10, 1–200, pls. 1–8. 1940); "the North American sub-divisions of Ranunculus," by Lyman Benson (Amer. Journ. Bot. 27: 799–807, 17 figs. 1940); "a revision of Laurentia and allied genera in North America," by Rogers McVaugh (Bull. Torr. Bot. Club 67: 778–798. 1940); "new combinations and new names in the Umbelliferae," by Mildred Mathias and Lincoln Constance (Bull. Torr. Bot. Club 68: 121–124. 1941); "a revision of Choisya," by Cornelius G. Muller (Amer. Midland Nat. 24: 729–742, 7 figs. 1940); "the American species of Hippocrateaceae," by A. C. Smith (Brittonia 3: 341–355, 12 figs. 1940); "a revision of the genus Chaenactis," by Palmer Stockwell (Contrib. Dudley Herb. 3: 89–168, pls. 22–45. 1940).

Recent articles of general interest to botanists are: "late Tertiary floras of the Great Basin and border area," by Daniel I. Axelrod (Bull. Torr. Bot. Club 67: 477–487. 1940); "some features of the structure of Toxicodendron diversilobum," Herbert F. Copeland and Bernice E. Doyel (Amer. Journ. Bot. 27: 932–939. 1940); "history of botanical exploration in Alaska and Yukon territories from the time of their discovery to 1940," by Eric Hultén (Botaniska Notizer 1940: 289–346. 1940); "Arizona localities of interest to botanists," compiled by T. H. Kearney (mimeographed, received 1941); "additional nomina generica conservanda: Pteridophyta and Phanerogamae," by T. A. Sprague (Kew Bull. Misc. Inf. no. 3: 81–134. 1940); "Gramineae of Nevada," by Jason R. Swallen (Contributions toward a flora of Nevada, no. 1, mimeographed, Washington, D. C.).—Ethel Crum.

PROCEEDINGS OF THE CALIFORNIA BOTANICAL SOCIETY

October 24, 1940. Meeting, 2093 Life Sciences Building, University of California, Berkeley, at 7 : 45 P. M. The President, Dr. Ira L. Wiggins, occupied the chair. Dr. Wilfred W. Robbins, Professor of Botany and Botanist in the Experiment Station, University of California, Davis, spoke on, "Alien Plants Growing without Cultivation in California."

November 14, 1940. Meeting, 2093 Life Sciences Building, University of California, Berkeley, at 7 : 45 P. M. The President, Dr. Ira L. Wiggins, occupied the chair. A nominating committee was appointed by the President, to submit nominations for officers of the Society for 1941, and asked to report at the December meeting. Mr. J. W. Stacey, of San Francisco, spoke on, "Distribution and Evolution of the Genus Carex in Western North America."

December 12, 1940. Meeting, 2093 Life Sciences Building, University of California, Berkeley, at 7 : 45 P. M. The President, Dr. Ira L. Wiggins, occupied the chair. Mr. William M. Hiesey, Carnegie Institution of Washington, Stanford University, California, spoke on, "Relations between Plants and Climates as Revealed by Transplant Experiments."

January 16, 1941. Meeting, 2093 Life Sciences Building, University of California, Berkeley, at 7 : 45 P. M. The President, Dr. Ira L. Wiggins, occupied the chair. Miss Ethel K. Crum, Chairman of the Nominating Committee, submitted the names of the following candidates: President, Professor E. B. Babcock; First Vice-President, Mrs. Roxana S. Ferris; Second Vice-President, Dr. Palmer Stockwell; Secretary, Dr. Lincoln Constance; Treasurer, Mr. William M. Hiesey. A motion, made and seconded to accept the report of the nominating committee, was passed unanimously. There were no nominations from the floor. Dr. G. Ledyard Stebbins, Jr., Associate Professor of Genetics, University of California, Berkeley, spoke on, "The Genetic Approach to Problems of Rare and Endemic Species."

February 20, 1941. Meeting, 2093 Life Sciences Building, University of California, Berkeley, at 7 : 45 P. M. The President, Professor E. B. Babcock, occupied the chair. Dr. Ralph W. Chaney, Chairman of the Department of Paleontology, University of California, Berkeley, gave an illustrated lecture on, "Tropical America, a Botancial Garden of the Past."—L. CONSTANCE, Secretary.

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A WEST AMERICAN JOURNAL OF BOTANY

Contents

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ALPINE FLORA OF SAN FRANCISCO MOUNTAIN, ARIZONA

Elbert L. Little, Jr.[1]

San Francisco Mountain, known locally as the San Francisco Peaks, is the highest point in Arizona and has the state's only definitely alpine area. The disjunct alpine flora of this isolated volcanic cone is, therefore, of special interest. Forty-nine species of alpine vascular plants, including four not recorded previously for the state and several others found nowhere else in Arizona, are represented in a spare-time collection made here by the author in 1938.

Although many botanists have visited San Francisco Mountain during the past half century, there has been no previous attempt to assemble a complete collection of the alpine flora or to prepare a description of the vegetation above the timberline. The author was stationed nearby at Fort Valley Experimental Forest, a branch of the Southwestern Forest and Range Experiment Station about nine miles northwest of Flagstaff. From this convenient base he made nine collecting trips to summits of the highest peaks during the growing season from June to September 1938, besides one trip in 1937 and two in 1939.

Geology and Geography

This eroded volcano (text fig. 1) is situated about ten miles north of Flagstaff, Coconino County, northern Arizona (mostly in T. 22 and 23 N., R. 7 E., Gila and Salt River Meridian, centering near latitude 35° 20′ N., longitude 111° 40′ W.). From a high timbered plateau within Coconino National Forest about 7000 feet above sea level, it rises abruptly more than a mile to a maximum elevation of 12,655 feet and forms a prominent landmark visible many miles from all directions.

A summary of the geology and geography of San Francisco Mountain, taken mainly from Robinson's (18) monograph, will serve as a background for the discussion of the alpine plants. The area was at no great height above the sea when volcanic activity in the form of lava flows began in the Pliocene epoch. In early Pleistocene, San Francisco Mountain with four smaller volcanoes was formed from about 38 cubic miles of lava and rose about 8800 feet above the plain. Afterwards the region was raised to its present height above sea level, and nearly four hundred small basaltic cinder cones were formed.

Since the volcano became extinct San Francisco Mountain has lost by erosion about three thousand feet or more than one-third

[1] Associate forest ecologist, Southwestern Forest and Range Experiment Station, which is maintained at Tucson, Arizona, by the Forest Service, United States Department of Agriculture.

Madroño, Vol. 6, pp. 65–96. July 11, 1941.

of its height but only about eight per cent of its volume. No trace of the former crater is left. A large interior valley, called the Inner Basin, was formed on the northeast side and was occupied by a glacier nearly two miles long probably in the late Wisconsin stage. This station was thought to be the southernmost for Pleistocene glaciation in the United States until evidence of glaciation was found a few years ago in the White Mountains of southern New Mexico; Pleistocene glaciation occurred also farther south than San Francisco Mountain on San Gorgonio Peak, southern California. As a result of erosion San Francisco Mountain (text fig. 1; pl. 5, fig. 1) now has the shape of a hollow, truncated cone about twelve miles or less in diameter at the base,

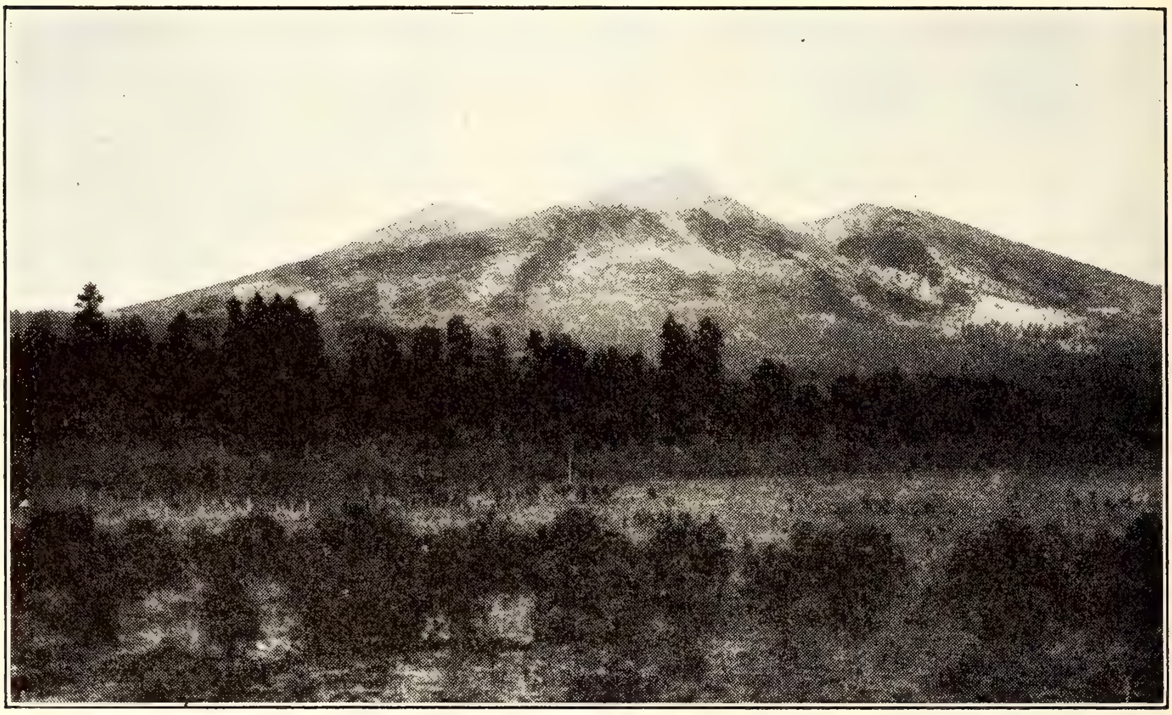

Fig. 1. San Francisco Mountain, as viewed from Fort Valley Experimental Forest on the southwest, is a symmetrical, eroded volcanic cone. Its three highest peaks are Humphreys Peak (left), Agassiz Peak (center) and Fremont Peak (right).

two miles in diameter at the top, and one mile high. Its slope is about 20 degrees at the top and gradually becomes less towards the base. The irregular rim forms a knife-edge divide between the outer slope and the Inner Basin. Along this crest line, which is continuous except on the northeast, are six peaks above 11,000 feet in elevation. The three highest, projecting above the timber line, are: Humphreys Peak, elevation 12,655 feet, on the northwest; Agassiz Peak, elevation 12,384 feet, on the southwest; and Fremont Peak, elevation 11,984 feet, on the south.

Previous Botanical Investigations

No references to alpine plants of San Francisco Mountain were found in reports of the United States Government exploring and surveying expeditions, though this mountain lay on the

route of several. In the United States National Herbarium are specimens of alpine plants collected on San Francisco Mountain by the following early collectors in the years indicated: E. Palmer, 1869; H. H. Rusby, 1883; M. E. Jones, 1884; Mr. and Mrs. J. G. Lemmon, 1884; E. L. Greene, 1889; F. H. Knowlton, 1889; D. T. MacDougal, 1891, 1898; J. W. Toumey, 1892; E. O. Wooton, 1892; C. A. Purpus, 1900; J. B. Leiberg, 1901; G. A. Pearson, 1908–1909. The Forest Service herbarium at Fort Valley Experimental Forest has specimens of about 25 alpine species collected by G. A. Pearson and others.

Hoffman (9) in 1877 noted that the timberline was irregular, approaching to within one thousand feet of the summit on the eastern side and five hundred feet on the western. Rusby (19) wrote in 1889 that at the summit grow only lichens and that the alpine flora, of which he named 6 species, begins one or two hundred feet below. This statement, perhaps the source of a similar one by Harshberger (8, p. 583), is not strictly correct. In a list of Arizona plants collected by E. A. Mearns, Britton (2) in 1889 mentioned 23 species from San Francisco Mountain, including about 6 occurring above timberline. The first meteorological studies in the alpine zone of San Francisco Mountain were made by D. T. MacDougal in August 1898, (3, p. 43–45).

There have been four detailed studies of the vegetation of San Francisco Mountain and vicinity from different viewpoints. First of these and the only one to include the alpine zone was Merriam's (13) biological survey in 1889. A timber survey of the forests of this area was made by Leiberg, Rixon, and Dodwell (11) in 1901 and 1902. Pearson's (16) detailed study of the forest types of San Francisco Mountain included measurement of environmental factors from 1917 to 1919 at five climatic stations in different zones from the base to the timberline. Hanson (7) in 1922 and 1923 conducted a similar series of climatic stations in his research on the vegetation of the four lower zones at the base of this mountain. The more recent summaries of Arizona vegetation by Nichol (15) and others contributed no additional information on alpine plants.

San Francisco Mountain is of special historical interest to biologists because it was here in 1889 that Merriam (13) made one of the first thorough investigations of the plant and animal life of a western locality and worked out his life zones or climatic zones. From the alpine zone, above 11,500 feet, on the "bleak and storm-beaten summit" of San Francisco Mountain, Merriam listed 20 species of vascular plants. He recognized also the subalpine or timberline zone, a narrow belt at an elevation of 10,500 to 11,500 feet, where the trees became stunted and prostrate, and included a list of 16 species attaining their maximum development here. Later, when he proposed his explanation of temperature control of the geographic distribution of animals and plants, Merriam (14) omitted the subalpine zone, which does not appear

to be distinct ecologically, and did not separate it from the Hudsonian or spruce zone.

Merriam's two lists totaling 34 species comprise the only detailed published study of alpine and timberline plants of San Francisco Mountain. This collection, which was made by F. H. Knowlton and deposited in the United States National Herbarium, contains specimens of a few other alpine species not mentioned by Merriam. *Corallorhiza maculata* (listed as *C. multiflora*) was recorded from timberline zone apparently through error, as the altitude mentioned on the label (*Knowlton 106*) is 10,000 feet. The author has collected specimens of all the others in Merriam's two lists except *Sagina saginoides* (*S. Linnaei*).

Discussion

Alpine areas above timberline on San Francisco Mountain occupy about two square miles, nearly all located on the slopes of Humphreys and Agassiz peaks (pl. 5, fig. 1). As here limited the alpine zone is that above the highest wind timber, "krummholz," or dwarf tree species (pl. 5, fig. 2). On this mountain such alpine scrub is represented by Engelmann spruce (*Picea Engelmanni* Parry) and bristlecone pine (*Pinus aristata* Engelm.). Though roads go about half-way up the mountain on four sides, the rocky alpine summits must be reached on foot.

Timberline is somewhat irregular and extends nearly one thousand feet higher up the southern and western exposures than the northern and eastern. In ravines on north-facing slopes finger-like areas of alpine vegetation reach down to lower levels. Typical alpine vegetation may occur in protected areas while trees grow on exposed ridges above. Besides the obvious effects of direction of slope and topography, drifting of winter snows is partly responsible for the irregularity of the timberline. After winter storms white clouds of snow are blown off Humphreys Peak into the Inner Basin. The best development of alpine meadows is at an elevation slightly below 11,500 feet at the extreme upper end of the Inner Basin where the deeper snow drifts do not disappear until midsummer. At one place here an alpine meadow merges laterally into a subalpine meadow.

Environmental factors. Climatic and edaphic factors affecting the alpine vegetation here probably are similar to those of other exposed western peaks. Coville and MacDougal (3) noted that air temperature at the summit of Agassiz Peak had less daily

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Explanation of the Figures

Plate 5. Alpine Zone of San Francisco Mountain, Arizona. Fig. 1. View from Fremont Peak northwest across the Inner Basin, showing treeless alpine summits of Agassiz Peak (left) and Humphreys Peak (right). Fig. 2. Wind-swept, dwarf Engelmann spruce (*Picea Engelmanni*) at timberline ridge on west side of Agassiz Peak. Alpine rock field or lichen association in background. Pearson's timberline climatic station was nearby. Fig. 3. Alpine meadow association, in which the dominant species, *Geum turbinatum,* forms mats of vegetation on a rocky slope.

PLATE 5. ALPINE ZONE OF SAN FRANCISCO MOUNTAIN, ARIZONA

variation than that at lower altitudes but found a greater difference between temperature of soil and air at the top than at lower levels.

In the absence of other instrumental records in the alpine zone, it may be of interest to summarize comparable data from Pearson's (16) timberline station (pl. 5, fig. 2) from 1917 to 1919 to indicate the climatic conditions under which the alpine plants are growing. During these three years the frostless period here, from June to September, varied between 101 and 113 days. Mean air temperature for the period from June to September was 47.9 degrees. Because of temperature inversion, or cold air drainage, night temperatures at timberline were little if any colder than at lower altitudes, but the days were decidedly colder. Annual precipitation at Pearson's timberline station was slightly higher than at lower zones, totaling 28.03 inches in 1917, 37.74 inches in 1918, and 52.05 inches in 1919. The P/E ratio, or precipitation divided by evaporation, for the interval from June to September was .812. Wind movement on the exposed ridge at timberline was relatively high.

During the winter months from November or December to March or April San Francisco Mountain has a white cap of snow, which buries and protects the dormant alpine vegetation. In April and May the snow melts in most places above timberline, exposing the dark-colored rock. However, on shaded slopes and areas of deep drifts, large snow banks remain until early July. In 1938 the last small patch of snow melted in the latter part of August. Frequent thunderstorms of cold rain occur in the summer rainy season from July to September. The first light winter snow in the alpine area usually falls early in October.

Above timberline soils are poorly developed and the slopes are largely covered with angular blocks or boulders of andesite and pyroxene dacite. Wind, frost action, and erosion all retard the formation and accumulation of soils on the steep slopes and make the establishment of vegetation difficult. Soil pockets occur in crevices, and in places spreading mats of vegetation hold the shallow soils and help to form more.

Plant associations. The alpine vegetation of San Francisco Mountain is poorly developed and the alpine flora impoverished, in comparison with alpine vegetation and flora of larger, higher mountains. Only two plant associations are distinguished here, the alpine rock field or lichen association and the alpine meadow or *Geum turbinatum* association. In the xerosere the former association gradually merges into and is succeeded by the latter, which is the climax. As no streams, lakes, or permanent snow drifts are present, there is no hydrosere.

In contrast, Cox (4) described on James Peak, elevation 13,260 feet, in Colorado, a much richer alpine vegetation. The alpine meadow, or *Geum turbinatum* association of San Francisco Mountain corresponds with the dry meadow associations on

James Peak, where *Carex rupestris* and *Geum turbinatum* are dominant. On James Peak, however, the dry meadow is succeeded by a climax alpine meadow association in which *Elyna Bellardi,* a species not found on San Francisco Mountain, is dominant. The various communities in hydroseres from wet stony areas, stream and lake margins, and snow drifts through scrub, moor, and wet meadow types to the climax alpine meadow of James Peak all are absent from San Francisco Mountain.

Alpine rock field. The alpine rock field or lichen association occupies most of the mountain summit of San Francisco Mountain, including exposed peaks and ridges (pl. 5, fig. 2). However, some unstable rock slides are almost without plants. This association is characterized by lichens, principally crustose and foliose, on the rock outcrops with vascular plants scattered among the boulders wherever there is sufficient soil. Even on the highest, exposed peaks a few seed plants can be found. Probably the most abundantly represented species or dominant species is the crustose lichen *Rhizocarpon geographicum* (L.) Lam. & DC. (determination verified by Dr. Carroll W. Dodge). Two species of foliose lichens, of which specimens were collected here previously for the Forest Service by F. W. Haasis and J. O. Veatch and determined by G. K. Merrill, are *Lecanora rubina* (Vill.) Ach. and *Parmelia conspersa* (Ehrh.) Ach. Mosses are less common than lichens and are found in crevices and to a lesser extent on boulders. *Hypnum revolutum* (Mitt.) Lindb. is characteristic of the shaded soil pockets. The moss species most commonly represented on dry outcrops is *Grimmia Doniana* Sm., which, according to Edwin B. Bartram who determined the two mosses, may be the first record for the state. The only alpine pteridophyte, *Cystopteris fragilis,* is commonly distributed in crevices.

The number of species of flowering plants represented in the alpine rock field is high and includes nearly all occurring above timberline. Of these the mat-forming pioneer species of the alpine meadow, *Geum turbinatum,* is most conspicuously represented. Five characteristic species of Caryophyllaceae here are *Arenaria Fendleri, A. sajanensis, A. verna, Cerastium Beeringianum,* and *Silene acaulis.* Three species of grasses commonly represented are *Festuca ovina* var. *brachyphylla, Poa rupicola,* and *Trisetum spicatum. Carex bella* is the sedge species most commonly represented, and *Luzula spicata* the typical rush. Other characteristic species in the rock field include *Polemonium confertum, Solidago ciliosa, Thlaspi Fendleri,* and *Pseudocymopterus montanus.* Typical pioneer species on rock slides are *Geum turbinatum, Primula Parryi, Senecio franciscanus,* and *Arenaria saxosa.* In shaded crevices and cliffs *Heuchera versicolor* f. *pumila* and *Oxyria digyna* are commonly represented.

Alpine meadow. The alpine meadow or *Geum turbinatum* climax association is developed on the more favorable sites, such

as at the upper end of the Inner Basin and ravines not far above timberline (pl. 5, fig. 3). However, the area occupied is only a small fraction of the alpine zone. Plants of the dominant species, *Geum turbinatum,* start as pioneers on rocky slopes and especially at the bases of rock slides. They spread vegetatively by creeping stems to form compact mats in which soil is built up and other plants become established to form an almost solid mantle of vegetation. If any species of vascular plants may be said to be abundantly represented above timberline, it is this. Other mat-forming species here include *Potentilla Sibbaldi* and *Silene acaulis.*

Most of the species listed under rock fields are commonly represented also in meadows. The following species of grasses and sedges are typical: *Festuca ovina* var. *brachyphylla, Trisetum spicatum, Carex bella, C. albo-nigra,* and *C. ebenea.* Other species of meadows include *Luzula spicata, Arenaria sajanensis, Cerastium Beeringianum,* and *Solidago ciliosa.* Scattered or rare in alpine meadows are individuals of the following species not observed elsewhere above timberline: *Phleum alpinum, Poa reflexa, Gentiana barbellata, G. monantha, Pedicularis Parryi, Veronica Wormskjoldii,* and *Erigeron simplex.*

Mosses of several species are present in alpine meadows but are not common. Liverworts of a single species, *Lophozia porphyroleuca* (Nees) Schiffn. (determination by Dr. A. W. Evans), were found above timberline. Not reported previously from Arizona, this species is represented sparingly in alpine meadows and more commonly in the subalpine forest.

This climax association is slowly spreading through mat formation by the dominant species, and all degrees of intermediate stages between rock field and meadow can be observed. The two associations sometimes are mixed together, for example near the bases of steep slopes where large boulders which have rolled down from above have a vegetation of lichens though surrounded by a climax meadow.

Above timberline growth begins in June, or possibly earlier on southern and western exposures. By the middle of June plants of the following species are in flower: *Thlaspi Fendleri, Geum turbinatum, Pseudocymopterus montanus,* and *Polemonium confertum.* Most of the alpine species blossom in July and August. Among the last species to begin flowering, in August and September, are *Gentiana barbellata, Erigeron simplex, Senecio franciscanus,* and *Solidago ciliosa.* Plants of *Geum turbinatum* continue to flower throughout the summer. By the first of October even the last late flowers have been killed by frosts and the vegetation has become dormant for the winter.

Geographic Distribution of Species. Four species of vascular plants found by the author on San Francisco Mountain apparently are here first recorded for the state with corresponding extensions of range. All have a northern distribution and reach their southern limits on this and similar mountain summits. The

alpines are *Juncus Drummondii, Erigeron compositus,* and *Erigeron simplex.* More unusual is *Botrychium lanceolatum,* a subalpine pteridophyte reaching the timberline. This circumboreal species has been recorded previously from only three western states, Washington, Wyoming, and Colorado. As the author (12) has noted, the station on San Francisco Mountain is the southernmost reported in North America and nearly four hundred miles southwest of the nearest known localities in central Colorado. A few other alpine species here have been found nowhere else in Arizona, but some occur also on Arizona's second highest mountain, Thomas or "Baldy" Peak, elevation 11,470 feet, in the White Mountains one hundred and fifty miles southeast.

Merriam (13) observed that many of the species above timberline on San Francisco Mountain are arctic-alpine circumpolar species widely distributed in arctic regions of North America and Eurasia, such as Alaska, Hudson Bay, Greenland, Spitzbergen, and Siberia, and extend far south on summits of such high mountain ranges, as the Sierra Nevada, Rocky Mountains, Alps, and Himalayas. However, after an interval of fifty years, there are fewer species in common with these more distant points, owing to increased knowledge and probably also to a trend toward a narrower concept of the species. As a result of such changes and of corrections in nomenclature, only one-half of the 34 species listed by Merriam (13) as occurring in the alpine and timberline zones now bear the same names.

The occurrence of disjunct arctic-alpine plants on San Francisco Mountain was explained by Merriam according to the present interpretation, that of migration southward during the glacial period and the ascension of mountain peaks as the temperature became warmer. He concluded that, as these species could not have reached here afterwards, the volcano could not be of more recent origin than the glacial period.

Rydberg (20) classified the alpine flora of the Rocky Mountains into ten groups according to geographical distribution, while Holm (10) in a detailed analysis of the alpine flora of Colorado distinguished four elements as to origin. The 49 alpine species of San Francisco Mountain fall into five more or less natural groups, according to their ranges as given in floras and manuals and in the phytogeographical treatises by Rydberg (20) and Holm (10). These groups are listed below with the abbreviations used in the list of species, the number of species in each, and the percentage of species in each.

	Number of species	Per cent
Arctic-alpine circumpolar species (CP)	15	30.6
North American arctic-alpine species (NA)	5	10.2
Rocky Mountain alpine species (RM)	24	49.0
Southwestern species (SW)	3	6.1
Endemic species (EN)	2	4.1

Thus, the relationships of the alpine flora of San Francisco Mountain are quite definitely northern with the floras of arctic and alpine regions. The 15 arctic-alpine circumpolar species, almost one-third of the total, are widely distributed in arctic regions in North America and Eurasia and on alpine mountain summits at lower latitudes. Two of these, *Arenaria sajanensis* and *Stellaria umbellata,* are recorded from Siberia but not from Europe, while the rest are listed from both Europe and Asia. A few have even wider distribution. *Cystopteris fragilis* is almost cosmopolitan and ranges to tropical America. *Phleum alpinum* and *Trisetum spicatum* are found also in alpine South America.

The 5 North American arctic-alpine species have a distribution from Greenland to Alaska, or slightly narrower, and southward on high western mountains but are not listed from Eurasia. The 24 Rocky Mountain alpine species occur in high mountains generally from Montana south to Colorado and Utah and on the highest peaks of New Mexico and Arizona. Some of these are found also in somewhat lower zones. Three southwestern species are confined to New Mexico and Arizona or slightly beyond and apparently have migrated up to the alpine area from lower zones, where they are more typical.

Only two alpine species, *Senecio franciscanus* Greene (5, p. 19–20), and an undescribed species of *Pedicularis,* are endemic to San Francisco Mountain, and neither furnishes a clue as to routes of migration. In his monograph Greenman (6, p. 29–30) listed only 6 collections of *Senecio franciscanus,* all from this mountain. Though *Senecio* is well represented in alpine regions with several species confined to Colorado, the species apparently most closely related to *S. franciscanus* are distributed nearby at lower zones in the same area. The undescribed species of *Pedicularis* is an endemic closely related to the widely ranging species, *P. Parryi* A. Gray. Several other alpine plants here have been proposed as new species, but these have been reduced to synonymy, with the exception of one or two retained as varieties of other species. However, a large number of endemic species is not to be expected on a geologically young volcanic cone.

Most of the alpine species of San Francisco Mountain are found also below timberline, especially in subalpine meadows. The following commonly represented species, as well as a few others, are confined to the alpine zone here: *Arenaria sajanensis, Silene acaulis, Polemonium confertum,* and *Senecio franciscanus.* A few, such as *Arenaria Fendleri* and *Thlaspi Fendleri,* are equally characteristic of the western yellow pine zone at the base of the mountain.

By comparing the alpine flora of San Francisco Mountain with similar plant lists from other southwestern peaks, it should be possible to trace the probable routes of the arctic-alpine plants in migrating to this newly formed volcano. Bailey's (1, p. 51–53) list of 60 characteristic species of the arctic-alpine zone in New

Mexico indicates a much richer alpine flora in the Sangre de Cristo Range at the southern end of the Rocky Mountains more than three hundred miles eastward. The nearest alpine peaks of the main Rocky Mountains are in Colorado about two hundred and fifty miles northeast. Thirty-eight of the 50 alpine species on San Francisco Mountain are included in Cox's (4) list of 196 alpine species on James Peak, Colorado. The high plateau of Arizona, on which San Francisco Mountain is located, is almost continuous with alpine summits in southern Utah two hundred miles northward and connects on the southeast with the White Mountains one hundred and fifty miles distant and with mountains in western New Mexico.

Raunkiaer's Life-forms. The 48 alpine species of seed plants on San Francisco Mountain were grouped also according to Raunkiaer's (17) life-forms. Phanerophytes are absent above timberline, and only four life-forms are represented. Most of the species (40) are perennial herbs classed as hemicryptophytes. The remaining 8 are listed below according to life-form. The 5 species of chamaephytes are: *Geum turbinatum,* the abundantly represented, mat-forming species; *Silene acaulis,* a typical cushion species; *Arenaria sajanensis, Saxifraga caespitosa* subsp. *exaratoides* var. *Lemmonii,* and *Potentilla Sibbaldi.* The single cryptophyte or geophyte species is *Senecio franciscanus,* which is especially successful on rock slides because of its creeping rhizomes. There are only 2 species of therophytes or annual herbs, *Androsace septentrionalis* var. *subumbellata* and *Gentiana monantha.*

As others have noted, the distinction between chamaephytes and hemicryptophytes is not sharp, and a few of the species classed as the latter might as well have been called chamaephytes. At any rate, the prevailing life-form here is that of low perennial herbs with rosettes and stems which, often retaining bases of old leaves, elongate slightly each year.

The biological spectrum of the alpine zone of San Francisco Mountain and Raunkiaer's revised normal spectrum are compared below, with percentages of species under each life-form. The slightly higher percentage of chamaephytes above that of the normal spectrum indicates a cold climate intermediate between the temperate hemicryptophytic climate and the chamaephytic climate of arctic regions.

	Raunkiaer's revised normal spectrum Per cent	Alpine zone of San Francisco Mountain Per cent
Phanerophytes	46	0
Chamaephytes	9	10.4
Hemicryptophytes	26	83.3
Cryptophytes	6	2.1
Therophytes	13	4.2

List of Alpine Species

This study is limited to the vascular plants above timberline on San Francisco Mountain. All species normally found at some distance above the irregular line of the last stunted individuals of tree species were included, regardless of their occurrence in other zones. As it was sometimes difficult to determine whether a species should be classed as alpine, a partial list of subalpine species reaching the timber line or slightly beyond is included as evidence that these species were not overlooked. For example, the shrubby species *Juniperus communis* var. *sibirica* and *Ribes montigenum,* which occur in protected rocky situations slightly above the highest spruces and pines, are not typically alpine.

In naming the specimens the author wishes to acknowledge the valuable assistance of several specialists. The author made determinations at the herbarium of the Field Station of the Bureau of Plant Industry at Sacaton, Arizona, and at the United States National Herbarium. Specimens of certain groups were further checked by the following specialists: Pteridophyta by Dr. Wm. R. Maxon, Gramineae by Dr. J. R. Swallen and Prof. J. J. Thornber, *Carex* by J. W. Stacey, *Juncus* by Dr. F. J. Hermann, *Ranunculus* by Dr. Lyman Benson, and Compositae by Dr. S. F. Blake. Determinations of all the remaining specimens have kindly been checked by Dr. T. H. Kearney. Nomenclature is that of the forthcoming Flora of Arizona, by T. H. Kearney and R. H. Peebles. The names thus are in accord with the International Rules of Botanical Nomenclature and are conservative.

Duplicate sets of the author's specimens have been deposited in the United States National Herbarium, herbarium of the University of Arizona, herbarium of the Sacaton (Arizona) Field Station, and herbaria of the Forest Service at the following localities: Washington, D. C.; Albuquerque, New Mexico; Southwestern Forest and Range Experiment Station at Tucson, Arizona, and Fort Valley Experimental Forest near Flagstaff, Arizona.

The 49 alpine species of vascular plants of San Francisco Mountain, including a single pteridophyte and 48 species of flowering plants, are grouped into 35 genera and 17 families. Specimens of two additional species were undeterminable. Largest families are Caryophyllaceae (a family well represented at northern points and high elevations) with 8 species, Compositae with 7, and Gramineae with 6 species. Principal genera are *Arenaria* and *Saxifraga* with 4 species each and *Carex* and *Potentilla* with 3 each. Rydberg (20, p. 92–93) lists from San Francisco Mountain an additional species, *Lloydia serotina* (L.) Sweet, which is omitted here because no herbarium specimen from Arizona could be located. The species are listed below with brief notes on habitat and abundance. Geographic distribution or range is abbreviated as explained above.

Polypodiaceae

Cystopteris fragilis (L.) Bernh. Crevices, alpine rock fields; common. CP.

Gramineae

Agropyron Scribneri Vasey. Loose rocks and gravel, alpine rock fields; scattered. The weak stems spread out in all directions over the rocks. RM.

Festuca ovina L. var. brachyphylla (Schult.) Piper. Alpine meadows and rock fields; common. CP.

Phleum alpinum L. Alpine zone, confined to climax alpine meadows; rare. CP.

Poa reflexa Vasey & Scribn. Alpine zone, in meadows; rare. RM.

Poa rupicola Nash. Alpine meadows and rock fields; common. RM.

Trisetum spicatum (L.) Richt. Alpine rock fields and meadows; common. CP.

Cyperaceae

Carex albo-nigra Mackenzie. Alpine rock fields and meadows; common. RM.

Carex bella L. H. Bailey. Alpine rock fields and meadows; the most commonly represented species of *Carex*. Flowers from June to September. RM.

Carex ebenea Rydb. Alpine rock fields and meadows; common. RM.

Juncaceae

Juncus Drummondii E. Meyer. This species, previously unrecorded for Arizona, was to be expected here, as it ranges from Alaska south in mountains to New Mexico and California. Rare in one alpine meadow at the upper end of the Inner Basin and commoner in nearby subalpine meadows. RM.

Luzula spicata (L.) DC. Alpine meadows and rock fields; common. CP.

Polygonaceae

Oxyria digyna (L.) Hill. Shaded rock crevices of alpine zone; uncommon. CP.

Caryophyllaceae

Arenaria Fendleri A. Gray. Typical of lower elevations, a depauperate alpine form common in alpine rock fields. RM.

Arenaria sajanensis Willd. Alpine rock fields and meadows; common. CP.

Arenaria saxosa A. Gray. Rock slides in alpine zone but more characteristic of lower zones; common. SW.

Arenaria verna L. Alpine rock fields and meadows; common. Nearly all the plants are densely glandular pubescent, but rarely glabrous plants are found. CP.

Cerastium Beeringianum Schlecht. & Cham. Alpine rock fields; very common. NA.

Sagina saginoides (L.) Britton. Alpine zone (*Knowlton 134*, U. S. National Herbarium); rare. Not collected by the author. CP.

Silene acaulis L. Alpine meadows and rock fields; commonly forming cushions or mats. CP.

Stellaria umbellata Turcz. Alpine rock crevices and meadows; uncommon. CP.

Ranunculaceae

Ranunculus inamoenus Greene var. alpeophilus (A. Nels.) L. Benson and var. subaffinis (A. Gray) L. Benson. Var. *subaffinis* is endemic to San Francisco Mountain. Alpine meadows and in mats of other plants; rare and scattered. RM.

Ranunculus sp. Alpine meadows and in mats of other plants; rare and scattered. An apetalous plant. Perhaps a reduced form of *R. pedatifidus* J. E. Smith, which sometimes lacks petals.

Cruciferae

Draba aurea Vahl var. aureiformis (Rydb.) Schulz. Alpine rock fields; common. NA.

Draba crassifolia Graham. Alpine meadows; rare. NA.

Thlaspi Fendleri A. Gray. Alpine rock fields and meadows; common. SW.

Crassulaceae

Sedum rhodanthum A. Gray. Alpine meadows and rock fields; common. RM.

Saxifragaceae

Heuchera versicolor Greene f. pumila Rosend. *et al.* Alpine rock ledges and crevices and also in alpine meadows; common. SW.

Saxifraga caespitosa L. var. Lemmonii Engler & Irmscher. Forming mats on alpine ledges and rock fields and occasionally in alpine meadows; not common. CP.

Saxifraga debilis Engelm. Shallow soils in shaded crevices, alpine rock fields; uncommon. RM.

Saxifraga flagellaris Willd. Mainly in crevices of alpine rock fields; not common. CP.

Saxifraga rhomboidea Greene var. franciscana (Small) Kearney & Peebles. Alpine rock fields and meadows; uncommon and scattered in mats of other plants. Var. *franciscana* perhaps is not worthy of recognition, as it differs only in smaller size and more compact inflorescences. These differences apparently are associated with the alpine habitat. RM.

Rosaceae

Geum turbinatum Rydb. *Sieversia turbinata* (Rydb.) Greene. Dominant in alpine meadows and a pioneer on rocks; by far the most abundantly represented species of flowering plants in the alpine area. RM.

POTENTILLA CONCINNA Richardson. Alpine rock fields; uncommon. RM.

POTENTILLA DIVERSIFOLIA Lehm. Alpine rock fields and meadows; not common. RM.

POTENTILLA SIBBALDI Haller f. (*Sibbaldia procumbens* L.) In mats in alpine meadows and slightly below timberline; common. CP.

UMBELLIFERAE

PSEUDOCYMOPTERUS MONTANUS (A. Gray) Coult. & Rose. In alpine rock fields and also in alpine meadows; common. RM.

PRIMULACEAE

ANDROSACE SEPTENTRIONALIS L. var. SUBUMBELLATA A. Nels. Alpine rock fields; common. CP.

PRIMULA PARRYI A. Gray. Alpine rock fields, including crevices and rock slides, and in meadows; common but scattered. RM.

GENTIANACEAE

GENTIANA BARBELLATA Engelm. Very rare and scattered in alpine meadows but more typical of lower zones. Plants above timberline are inconspicuous until they flower in September. RM.

GENTIANA MONANTHA A. Nels. In mats of other plants in alpine meadows; rare. RM.

POLEMONIACEAE

POLEMONIUM CONFERTUM A. Gray. Alpine rock fields and also in meadows; common. RM.

SCROPHULARIACEAE

PEDICULARIS sp. Rare in climax alpine meadows and common below timberline. Previously referred to *Pedicularis Parryi* A. Gray. However, Dr. Francis W. Pennell, whom I accompanied on a field trip here to collect additional material, is describing the San Francisco Mountain plant as a new, endemic species. EN.

VERONICA WORMSKJOLDII Roem. & Schult. Commoner below timberline, rare in alpine meadows. NA.

COMPOSITAE

ANTENNARIA APRICA Greene. Alpine rock fields; uncommon. RM.

ANTENNARIA UMBRINELLA Rydb. Alpine rock fields and meadows; uncommon. RM.

ERIGERON COMPOSITUS Pursh. Reported previously from Greenland to Alaska and south to Colorado, Utah, Nevada, and California. Very rare in an alpine meadow and in rock cliffs at timberline. NA.

ERIGERON SIMPLEX Greene. Previously known from Montana south to Colorado, New Mexico, and California. Though this species typically is radiate, some of the plants here are discoid or

nearly so. Scattered and uncommon in mats of other plants in alpine meadows. RM.

SENECIO FRANCISCANUS Greene. Endemic to the alpine zone of San Francisco Mountain, where it is commonly represented on rock slides. Discovered in 1884, but the type was collected by Greene in 1889. EN.

SOLIDAGO CILIOSA Greene. Alpine rock fields and meadows; common. RM.

TARAXACUM sp. Possibly a new record for the state, but the scarce material was undeterminable. In mats of other plants in alpine rock fields; very rare.

PARTIAL LIST OF TIMBERLINE SPECIES

Specimens of the 24 additional species in this partial list of timberline species were collected by the author in the wind timber or subalpine meadows at timberline or slightly above.

Botrychium lanceolatum (S. G. Gmel.) Angstr.
Woodsia oregana D. C. Eaton
Juniperus communis L. var. sibirica (Burgsd.) Rydb.
Bromus ciliatus L.
Poa Fendleriana (Steud.) Vasey
Poa pratensis L.
Sitanion Hystrix (Nutt.) J. G. Smith
Carex Haydeniana Olney
Carex siccata Dewey
Luzula parviflora (Ehrh.) Desv.
Anemone globosa Nutt.
Aquilegia chrysantha A. Gray
Ribes montigenum McClatchie
Potentilla Hippiana Lehm. var. diffusa Lehm.
Potentilla subviscosa Greene
Rubus strigosus Michx. var. arizonicus (Greene) Kearney & Peebles
Geranium Richardsonii Fisch. & Trautv.
Viola canadensis L.
Epilobium angustifolium L.
Epilobium saximontanum Haussk.
Moneses uniflora (L.) A. Gray
Mertensia franciscana Heller
Penstemon Whippleanus A. Gray
Agoseris purpurea (A. Gray) Greene ?

SUMMARY

San Francisco Mountain, elevation 12,655 feet, is an isolated volcanic cone located about ten miles north of Flagstaff, Coconino County, northern Arizona. The highest point in the state, it has a disjunct alpine flora which is Rocky Mountain alpine and arctic-alpine circumpolar in relationships. Two plant associations are distinguished in the alpine zone here, the alpine rock field or

lichen association on most of the rocky summit and the alpine meadow or *Geum turbinatum* climax association on limited, more favorable sites. Based upon collections by the author in 1938, 49 species of alpine vascular species and 24 additional timberline species are listed with brief notes on habitat and abundance. Four of these are previously unrecorded for the state: *Botrychium lanceolatum* (subalpine at timberline), *Juncus Drummondii, Erigeron compositus,* and *Erigeron simplex.*

Tucson, Arizona,
May, 1940.

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MARY FISK SPENCER

Mary Fisk Spencer died in San Diego, California, December 27, 1940. She was within twelve days of completing her one hundredth year. For fifty of those years, in spite of weak eyesight and handicapped by poor health, she had been an indefatigable botanizer; from 1878 to 1914 in Central and Southern Europe, and from 1915 to 1928 in southern California, chiefly in the arid sections of San Diego County. Her collections are found in the leading herbaria of Europe and America and in the private herbaria of many specialists, especially in Europe. Her death marks the passing of an outstanding amateur botanist.

Mary Evelyn Fisk was born at Brecksville, Ohio, January 8, 1841, the daughter of John Shipley Fisk and Anne Clapp Clark, both of whom were from New England. Her father, a master machinist, changed his residence frequently, being in charge successively of iron works in Knoxville, Tennessee, Franklin Falls, Ohio, and Cleveland, Ohio. As a result of change of residence and financial difficulties Miss Fisk's education was badly interrupted. When she was fifteen she enrolled in the Preparatory Department of Oberlin College, which was then almost the only coeducational institution in the middle west, if not in the entire country. A year of teaching followed, after which she enrolled in the Literary Department of the College for the years 1858–1859 and 1860–1861. A bank failure put an end to her college work.

Miss Fisk was musically gifted and while at Oberlin must have received considerable musical instruction, since, then as now, Oberlin was giving great attention to music. During the early eighteen-sixties she taught private music classes in and about Cleveland, but about 1865 was able to enter the old Boston (Massachusetts) Music School for study under B. F. Baker; she graduated there, then taught music privately in Boston. However, she wanted further training and by 1874 was studying at the Royal Conservatory of Music in Munich, Germany. After two years of strenuous work she suffered a nervous breakdown, and was thereafter compelled to lead an outdoor life.

During this period of European study she met James MacGoffin Spencer, who had gone to Munich in 1874 to study chemistry. They were married on July 28, 1878, and until September 1914, when they returned to the United States to live, resided in Munich. Mr. Spencer had been for six years Professor of Mathematics in the National Deaf and Dumb College in Washington, D. C. After a severe illness he was obliged to lead a life of leisure, which he diversified by travel and study. Thus it was necessary for both Mr. and Mrs. Spencer to have a rather quiet, outdoor life; and their means, though modest, permitted extensive travel.

During the years that Miss Fisk was in Oberlin she became a devoted admirer of Dr. James Dascomb (M. D. Dartmouth, 1833),

PLATE 6. MARY FISK SPENCER. Photograph taken about 1925.

who was "Professor of Chemistry, Botany and Physiology" at Oberlin from 1834 to 1878, and Librarian from 1855 to 1873. Through his influence she developed a love of botany, which after her marriage became a life passion. In company with her husband she visited most of the countries of Central and Southern Europe, and wherever she went she made extensive collections of the native flora. These collections she exchanged with leading botanists and herbaria, and thus assembled a herbarium of more than 12,000 sheets of vascular plants, chiefly from Central and Southern Europe, with a few from Norway, the British Isles, North Africa and Asia Minor.

This herbarium was later presented to Oberlin College. It constitutes the chief part of the European section of the College Herbarium which now contains about 100,000 sheets of vascular plants, and 50,000 of nonvascular plants, housed in steel, mothproof cases in a fireproof addition to the present botany building. In November 1900 in a letter to Professor Albert A. Wright of Oberlin, who had been Professor of Geology, Botany and Zoology after Dr. Dascomb's retirement, Mrs. Spencer wrote "I have been collecting for over twenty years, and have a large proportion of the plants of Central Europe which I intend, after I shall have made the collection as complete as I can, to present to Oberlin as an expression of affectionate regard for our dear Prof. Dascomb of blessed memory." Although her sight and health were even then failing she continued to build up her herbarium, the first installment of which was given to the College in 1908. She stipulated that the collection be maintained as a separate unit, and be called "The Spencer collection of European Plants, in memoriam Professor James Dascomb." She herself was in the United States from 1908 to 1910 to visit friends and to supervise the installation of the herbarium. She returned to Europe in the fall of 1910, where she continued to reside until just after the outbreak of the first world war. Three years of this time were spent in Corsica, where she made extensive collections that were later given to Oberlin.

After January, 1915, Mrs. Spencer resided in San Diego, California, until her death there on December 27, 1940. Mr. Spencer died May 13, 1920, in Burlington, Vermont.

In the arid and semiarid areas of San Diego County, Mrs. Spencer found a new and intensely interesting flora. Until her eyesight and health failed completely in 1927 she spent weeks at a time at all seasons of the year collecting in the desert regions as far south as the Mexican border. Many of the plants which she herself was unable to identify were determined at Gray Herbarium, a few by Dr. Greenman at the Missouri Botanical Garden and some of her last collections by Miss Fidella G. Woodcock, Curator of Plants in the Natural History Museum, San Diego. Soon after arriving in San Diego, she become acquainted with Mr.

C. H. Orcutt, from whom she obtained much assistance. A complete set of her California collections, with some from Arizona were also given to Oberlin College, the last installment being received in February, 1928. There were approximately 3000 numbers, many species being represented by several specimens collected in different seasons, at different altitudes, and from different ecological areas. FREDERICK GROVER, Oberlin College, Ohio.

NEW SPECIES OF VASCULAR PLANTS FROM THE NORTHWEST COAST

GEORGE NEVILLE JONES

During the preparation of a manual of botany of the Northwest Coast, covering the vascular flora of the region west of the Cascade Mountains from British Columbia to Oregon, two additions to the number of described species must be recorded and a new nomenclatural transfer is necessary at this time. In citing specimens, the following abbreviations are used: Gray Herbarium of Harvard University (G); Missouri Botanical Garden (Mo); University of Illinois (UI).

In treating the willows of the area west of the Cascade Mountains it has been necessary to re-examine that small group of species closely related to *Salix Geyeriana* Anderss. The conclusion has been reached that the willow of this group occurring west of the Cascade Mountains is specifically distinct from the eastern Washington and Rocky Mountain *S. Geyeriana,* and the following nomenclatural combination is herewith proposed:

Salix meleina (J. K. Henry) comb. nov. *S. Geyeriana* Anderss. var. *meleina* J. K. Henry, Fl. So. Brit. Columbia 98. 1915. *S. Geyeriana meleina* Ball, in Abrams, Ill. Fl. Pacific States 1: 506. 1923.

Salix Geyeriana is a smaller shrub with densely glaucous branchlets, the pubescence of the leaves is whitish-sericeous, the capsules somewhat longer, and the style obsolete. It is not known to occur west of the Cascade Mountains.

Delphinium splendens sp. nov. Herba perennis; radicis fibris elongatis vel subfusiformibus, lignosis; caulibus strictis 1–2 m. altis, simplicibus, glaucis, fistulosis; foliis palmatim 5–7-lobatis, 10–30 cm. latis; racemis elongatis, pedicellis glabris, quam floribus longioribus, adscendentibus; floribus 15–20 mm. longis; sepalis caerulescentibus, intus glabris, extus puberulis; calcare 8–10 mm. longo, patente vel ad apicem subcurvato; petalis 4, albicantibus, spatulatis, obtusis, 8–10 mm. longis, lamina ungueque hirtulis; staminibus ca. 25; antheris ovalibus 1.5 mm. longis; folliculis 3, erectis, rectis, glabris vel subglabris, tenuiter

reticulato-venulosis, 7–12 mm. longis, ad apicem nempe truncatis, in stylum abrupte abeuntibus; pedicellis fructigeris erectis vel adscendentibus; seminibus 3 mm. longis, costis in alas hyalinas productis.

Perennial; stem glaucous, leafy, simple, glabrous throughout, hollow, 1–2 m. tall, arising from a fascicle of elongate or somewhat fusiform woody roots; leaves palmately 5–7-lobed, 10–30 cm. broad, cleft about half way to the middle into oblanceolate, coarsely dentate, cuneate-based acute lobes, dark green, sparsely pilosulous above especially along the veins, pale green and grayish pilosulous-puberulent beneath; petioles glabrous, 10–15 cm. long, longer than the blades; racemes narrow, many-flowered, 25–50 cm. long; pedicels glabrous, slender, not longer than the flowers, the lower ones 8–15 mm. long at flowering time, ascending; flowers 15–20 mm. long; sepals dull blue, green-veined, glabrous within, puberulent outside; spur 8–10 mm. long, puberulent outside, acutish or obtuse, straight, horizontally spreading, or very slightly curved toward the tip; petals 4, whitish, spatulate, obtuse, 8–10 mm. long, the blade and claw hirsutulous; stamens about 25; anthers oval, 1.5 mm. long, glabrous; filaments 3–5 mm. long, translucent, dilated below, glabrous to sparsely pilosulous; follicles 3, erect, straight, glabrous or nearly so, somewhat reticulate-veiny, 7–12 mm. long, the style 3–4 mm. long, the follicle somewhat truncate at the apex, abruptly terminating in the style, the fruiting pedicels erect or ascending; seeds 3 mm. long, the angles produced into hyaline wings. The synonymy is as follows:

Delphinium scopulorum glaucum sensu Piper, Contr. U. S. Nat. Herb. 11: 280. 1906, Henry Fl. So. Brit. Col. 138. 1915; *D. glaucum* sensu Piper & Beattie, Fl. N.W. Coast 160. 1915, G. N. Jones, Univ. Washington Publ. Biol. 5: 153. 1936, *op. cit.* 7: 82. 1938, not Wats. Bot. Calif. 2: 427. 1880.

ALASKA: Chilkat Valley, *Walker 1070* (Mo). WASHINGTON: [Mount Rainier] Upper Valley of the Nisqually, July 14, 1896, *O. D. Allen 248* (type UI, isotype Mo); Swauk River, *Sharples 78* (UI); Yakima County, *Brandegee 615* (UI); Olympic Mountains, *Elmer 2577* (Mo), *Piper* in 1890 (Mo), *G. N. Jones 10735* (UI).

This northwestern larkspur has been passing as *Delphinium glaucum* Wats., a species described from the Sierra Nevada of California in 1876. It grows in subalpine meadows and along streams in the Cascade and Olympic mountains, from Alaska to Oregon. From the Californian *D. glaucum,* this newly described plant differs principally in its smaller flowers, shorter spurs, shorter pedicels, the smaller whitish petals, glabrous anthers, shorter filaments, shorter follicles with a truncate apex, and the leaves being sparsely pilosulous above and less deeply lobed. It is possible, in fact, to identify sterile specimens by the leaf-characters alone.

Sedum nesioticum sp. nov. Perenne, rosulatum, rhizomate horizontali lignoso; caulibus erectis, e basi excurvantibus, 10–30 cm. altis, vulgo sub anthesi aphyllis; foliis plerumque basilibus, numerosis, aggregatis nec non imbricatis, rosulatis, lineari-lanceolatis, teretibus vel subteretibus, succulentis, bene epapillatis, laete viridibus, nunquam scariosis, 1.5–3 cm. longis, integris; cymis effusis, 4–10 cm. latis, 3–7 dichotomis, floribus pulchre luteis, secundis; petalis discretis, lanceolatis, ca. 1 cm. longis; sepalis aequalibus, lanceolatis, acutulis, 5 mm. longis; staminibus quam petalis subbrevioribus; antheris 1 mm. longis; folliculis 6–7 mm. longis, apice subulato suberecto; seminibus obovoideis, levibus, 1 mm. longis.

Perennial, tufted, with a woody horizontal rhizome; stems erect, curved upward at the base, 10–30 cm. tall, usually leafless at flowering time; leaves chiefly basal, numerous, crowded but not imbricated, tufted, linear-lanceolate, terete or nearly so, succulent, smooth, not at all papillate, bright green, not becoming scarious, 1.5–3 cm. long, entire; cyme loose, 4–10 cm. broad, 3–7-forked, the branches becoming divergent or even somewhat recurved, the short-pedicelled bright yellow flowers secund upon the branches; petals distinct, lanceolate, acute or acuminate, about 1 cm. long; sepals equal, lanceolate, acutish, smooth, 5 mm. long; stamens slightly shorter than the petals; anthers 1 mm. long; follicles 6–7 mm. long, the subulate tips suberect; seeds obovoid, smooth, striate, 1 mm. long.

British Columbia: rocky bluffs, Victoria, July 21, 1918, *W. R. Carter; C. F. Newcombe 23* (G). Washington: islets, Gulf of Georgia, *L. F. Henderson 1686* (type, G); Friday Harbor, *S. M. & E. B. Zeller 808* (G); cliffs, Waldron Island, *H. C. Cowles 475* (G, Mo).

This newly described Puget Sound plant is not accounted for in Fröderström's recent monograph (Acta Horti Gothoburgensis 5–10, App.:1930–1936) or in the revision of the North American species by Britton & Rose (N. Am. Fl. 22: 7–74. 1905). It is evidently related to *Sedum stenopetalum* Pursh, for which it has commonly been passing, but it is a larger plant than that species. It can be distinguished in the herbarium by the facts that the leaves and sepals are perfectly smooth, not at all papillate, and that the inflorescence is larger and with the branches more divergent. The petals are longer, acute or acuminate, but not mucronate. The carpels are somewhat larger. So far as is known at the present time *S. nesioticum* is confined to the islands of the northern part of Puget Sound and adjacent British Columbia, hence the specific name. *Sedum stenopetalum* Pursh is a perfectly distinct species growing in the mountains from Alberta to New Mexico, and extending as far westward as eastern Washington.

University of Illinois, Urbana,
September 26, 1940.

NOTEWORTHY PLANTS FROM IDAHO

Arthur Cronquist

During the summer of 1939 the writer had opportunity to make extensive collections in Clark and Fremont counties, Idaho. Several specimens apparently represent plants previously not known to occur in the state and others represent range extensions within the state. All numbers cited are the author's own collections and, unless otherwise noted, duplicates of each number have been deposited in the herbaria of the Utah State Agricultural College, Logan, (UtS), the Missouri Botanical Garden (MB), and the University of Idaho, Southern Branch, Pocatello.

Agropyron Saundersii (Vasey) Hitchc. is recorded by Hitchcock (4) from only two localities, Veta Pass, Colorado, and Salt Lake City, Utah. It was collected in Fremont County three times during the season: along the Idaho-Wyoming border near Squirrel Creek east of Ashton, *1686* (UtS, MB); along railroad tracks at St. Anthony, *1773;* subalpine north slopes of Mount Jefferson, southwest of Henry's Lake, *1874*. At the last mentioned station the species was growing intimately with *Agropyron Scribneri* Vasey, but without apparent intergradation.

Agropyron Scribneri Vasey is recorded by Hitchcock (4) from Montana, Wyoming, Utah, and Nevada, among other states, but not from Idaho. It was collected on subalpine slopes of Mount Jefferson, Fremont County (*1873*).

Carex Hepburnii Boott is not recorded by Mackenzie (6) from Idaho although he mentions having seen specimens from all bordering states except Utah. The species was collected at 9000 feet on rocky, subalpine slopes east of Mount Jefferson, Fremont County (*1891*).

Carex occidentalis L. H. Bailey is recorded by Mackenzie (6) from Utah, Nevada, and southward. The species was collected under an open stand of limber pine, at 9500 feet, on a high ridge above West Camas Creek, north of Kilgore, Clark County (*1443*); it was associated with *Poa epilis* Scribn. and with several other species of *Carex*.

Cardamine unijuga Rydb. is recorded by Rydberg (8) from Wyoming and Montana. It was collected in standing water an inch or so deep at the edge of Big Springs, Fremont County (*1599*).

Saxfraga oppositifolia L. is known in western United States from comparatively few stations. Fernald (1, p. 7) presents a range map showing collections apparently from the Wind River Mountains of Wyoming, Yellowstone Park and adjacent Montana, and again from what appear to be the Bitterroot Mountains, along the Idaho-Montana border. The specimen was found growing

in dense extensive mats at 10,000 feet on north exposures just below the continental divide a mile southeast of the summit of Mount Jefferson, Fremont County. It was almost entirely past flowering at the time of collection (August 1) and hence is represented by only a single scanty sheet (*1906*, UtS).

Euphorbia Esula L. is a recent introduction from Europe. Hanson and Rudd (3) record it from two localities in Idaho, one from the panhandle at the north end of the state, the other apparently from the vicinity of Kilgore, Clark County. It was collected along the roadside near Medicine Lodge Creek, north of Small, Clark County, about forty miles west of the Kilgore station (*1931*).

Penstemon Whitedii Piper subsp. tristis Pennell & Keck is recorded by Keck (5) from the Salmon River twenty-three miles above Salmon City, and from several localities in Custer County, as far east as Mackay. This species was collected on an isolated sandstone outcrop in a limestone region north of Spencer, Clark County (*1339*); it was associated with *Hackelia patens* (Nutt.) Johnst., *Phacelia leucophylla* Torr. and *Castilleja fasciculata* A. Nels. It was not seen elsewhere in the area.

Brickellia oblongifolia Nutt. subsp. **typica** comb. nov. *B. oblongifolia* Nutt. var. *typica* Robins. Mem. Gray Herb. 1: 104. 1917.

Brickellia oblongifolia Nutt. subsp. **linifolia** (Robins.) comb. nov. *B. oblongifolia* Nutt. var. *linifolia* Robins., Mem. Gray Herb. 1: 104. 1917.

This subspecies is recorded by Robinson (7, p. 104) from Colorado, Utah, and southward, the Idaho area supposedly being occupied by subsp. *typica*. A collection from the south side of basalt rocks in St. Anthony City Park, Fremont County (*1474*) is apparently subsp. *linifolia*. A previous collection from the same station (*687*) is transitional to subsp. *typica*. It appears that subsp. *linifolia* is the more southerly representative of the species and that the collections cited above represent an extreme northward extension of its range. The habitat from which the specimens were taken simulates very closely what might be expected in hotter and drier more southern localities. In view of this difference in range var. *linifolia* Robins. may now be given subspecific status.

Chrysothamnus nauseosus (Pall.) Britt. subsp. glareosus (Jones) Hall & Clem. is recorded by Hall and Clements (2) from southern Utah and northern Arizona. A collection from the United States Sheep Station, near Dubois, Clark County (*1995*), agrees with this form in the glabrous achenes and puberulent involucres, but is taller than reported by Hall and Clements (6 or 8 dm. instead of 3 dm.). A previous collection (*854*) from the same station was made in 1937. The plant is not generally dis-

tributed through the area, and was found only on a lava reef near the station headquarters.

CHRYSOTHAMNUS NAUSEOSUS (Pall.) Britt. subsp. LEIOSPERMUS (Gray) Hall & Clem. is recorded by Hall and Clements (2) from southern Utah, southern Nevada, and the borders of California. A form having slightly wider leaves than are accorded to this subspecies, but otherwise agreeing fairly closely with the description given by Hall and Clements, was collected on the southern exposure of an extremely dry limestone cliff below the forks of Irvin Creek, northeast of Argora (*1965*). It will be noted that both of the *Chrysothamni* referred to above have glabrous achenes, an uncommon character in *C. nauseosus,* and that both were collected in extremely dry rocky situations, more or less simulating the normal habitat of the plants in more southern areas. It is suggested that further exploration may reveal these supposedly southern forms to be more widespread than has been previously believed, occurring in hot dry areas often passed up by collectors as being unworthy of inspection.

CHRYSOTHAMNUS PARRYI (Gray) Greene subsp. HOWARDII (Parry) Hall & Clem. is reported by Hall and Clements (2) from Wyoming and adjacent states, but not from Idaho. This subspecies is apparently represented by a collection from Red Conglomerate Peaks, east of Argora, Clark County (*1940*). The plants, growing on bare rocks at 9500 feet, are much reduced and superficially resemble certain species of *Haplopappus* more than *Chrysothamnus.* The upper leaves are distinctly elongate and surpass the heads as in subsp. *Howardii* but the leaves are more nearly glabrous as in subsp. *attenuatus* (Jones) Hall & Clem. Other characters are more nearly those of subsp. *Howardii,* and the collection is with some hesitancy so referred.

Intermountain Herbarium,
Utah State Agricultural College, Logan,
March 7, 1940.

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THE ALASKA CEDAR IN CALIFORNIA

Herbert L. Mason

Many rumors have been current relative to the occurrence of both the Alaska cedar, *Chamaecyparis nootkatensis* (Lamb.) Spach, and the western larch, *Larix occidentalis* Nutt., in California. These rumors have been particularly tantalizing since the descriptive evidence seemed so convincing. However, they were not vouched for by specimens. Recently, a collection from northwestern California clearly demonstrates the occurrence of *Chamaecyparis nootkatensis* in our flora. Mr. Oliver V. Matthews of Salem, Oregon, collected the species in 1939 on the northeast slope of Mount Emily in northwestern Siskiyou County and Dr. Doris Gillespie Niles of Humboldt State College, reports having seen it on Little Grayback farther to the west. Both localities are a little over two miles south of the Oregon line. Specimens of the Mount Emily material are deposited in the herbarium at Rancho Santa Ana Botanic Garden, Anaheim, California. Mr. Matthews reports that at Mount Emily the plants are associated with *Abies shastensis, Picea Breweriana, Pinus monticola, Libocedrus decurrens* and *Taxus brevifolia.*

Department of Botany, University of California,
Berkeley, February 15, 1941.

REVIEWS

The Ferns and Fern Allies of Wisconsin. By R. M. Tryon, N. C. Fassett, D. W. Dunlop, M. E. Diemer. Frontispiece. Pp. v + 158 with 214 figures and 76 maps. Published by the Department of Botany, University of Wisconsin, Madison. May, 1940. Price $1.00.

The work treats three families of ferns and five families of fern allies as they occur in Wisconsin. The introduction contains directions for the use of the keys and closes with a well directed plug for the American Fern Society. A brief statement of the meteorology, geology, and physiography of Wisconsin precedes the taxonomic treatment. The keys are replete with references to text figures illustrating the terminology, a practice which should facilitate their use. The illustrations are largely halftones, most of which are from excellent photographs; a few have suffered somewhat at the hands of the printer in that their blackness often obscures the detail. Drawings are well done and excellently reproduced. Distribution maps, which are liberally used, give a clear picture of the range of each species. In some cases the limestone areas are mapped showing the correlation between the distribution of the species and the occurrence of limestone. The value of such maps cannot be overestimated. They serve a very useful purpose in interpreting the plant geography of the region as well as in directing botanists to areas where further field work is needed. The chores of the four-fold authorship are divided between a fern specialist, a director of the project, an illustrator

PLATE 7. CHAMAECYPARIS NOOTKATENSIS. A group of small trees (foreground) on Mount Emily, Siskiyou County, California. Photograph by Oliver Matthews.

and a photographer. Over all, an angel spread his wings—Martin J. Gillen, "a loyal alumnus, an enthusiastic conservationist." We wish to encourage more such works and more such angels.—HERBERT L. MASON.

Forests and Trees of the Western National Parks. By HAROLD E. BAILEY and VIRGINIA LONG BAILEY. Pp. x + 129 with 71 text figures. Conservation Bulletin no. 6, National Park Service. United States Government Printing Office, Washington, D. C. 1941. Paper, $.25.

This valuable contribution to the literature of the national parks begins with a short introductory discussion of forest conservation, life zones, structure and functions of a tree and plant associations. The three general forestal regions (Pacific Slope, Rocky Mountain, Southwestern) in which the western national parks are located are briefly characterized. The forest associations and topographic features of the western parks, including those of Alaska and Hawaii, are then treated in some detail. Field keys to the genera and species of trees, non-technical descriptions and general information amount to approximately one-half of the content. A well-selected bibliography and an index to the common and scientific names complete the volume which is printed in clear type and beautifully illustrated with half-tones from photographs. The authors are to be congratulated on this attractive and readable booklet which will be very much appreciated by botanists and foresters as well as by the vacationing public.—ETHEL CRUM.

A Manual of the Higher Plants of Oregon. By MORTON E. PECK. Pp. 1–866, with 1 plate, 1 map and 90 figures. Binford & Mort, Portland, Oregon, 1941. Price $5.00.

The appearance of a usable manual covering the flora of any state which has not previously been so endowed is an event of the utmost interest to all students of plants. Especially is this true when the book is as thoroughly excellent and generally attractive as this one! There has, heretofore, never been any manual or combination of manuals which would permit satisfactory determination of plants from all parts of Oregon. Furthermore, no one previously has attempted to gather into one volume the various entities described from the state since the appearance of Howell's "Flora of Northwest America," about forty years ago. A very rough tabulation indicates that approximately 250 of these recently described entities, including two genera, collected into the present book, have never before been available in a manual or flora. If the author had performed no other service than to glean these from the scattered literature, characterize them fully and key them out, he would merit unstinted gratitude.

Even those persons who have had considerable experience with the vegetation of the area in question will, I am sure, be amazed at the size of its flora, as revealed in the present volume.

There are included 118 families, 701 genera and 3203 species—more than three-fourths the number of species recorded from California in Jepson's "Manual," in 1925. The area of Oregon is only three-fifths that of California. This suggests a degree of diversity for the flora of Oregon at least equal to that of the California flora, which has long been famous for its high degree of diversity coupled with remarkable endemism.

An introductory survey of the physiographic and floristic features subdivides Oregon into the following nine major "plant areas": northern coast, northern coast mountain, Willamette Valley, Rogue-Umpqua, southern coast, southern coast mountain and Siskiyou, Cascade, eastern Oregon (with five subordinate sections) and Blue Mountain. These represent the remarkable blending of at least six floristic elements: the northwestern coniferous forest, the Cascade, the Rocky Mountain, the Great Basin, the Californian and the Klamath-Siskiyou, a fact which helps to explain the large number of species native to the state. Each area is briefly summarized as to topography, geology, climate and plant assemblages. Important concentrations of endemic species are shown to occur particularly in the Siskiyou and southern coast mountains, Wallowa and Steens mountains, and in the gorges of the Columbia and Snake rivers. This excellent summary is made particularly valuable by the author's thorough familiarity over a long period of years with nearly every corner of the state.

The book is attractively bound in green cloth and is so firmly constructed that it should hold up well even under intensive field usage. Each family, genus and species is carefully keyed out, and for each species there is provided an English name, a full description, and a brief expression of its local and general range. The author bravely discards the traditional "Oregon Myrtle," often claimed locally to be "native only to Oregon and the Holy Land," for the more accurate "California Laurel." All subspecific entities are given the status of "variety," necessitating most of the new combinations proposed. The International Rules are strictly adhered to in the matter of capitalization of all specific epithets which are derived from personal names, or are generic or vernacular names. There is a notably large glossary of technical terms accompanied by ninety helpful illustrations of plant parts; thirty-six pages of index to families, genera and species, including both technical and English names, and their synonyms, conclude the volume.

Mr. J. William Thompson has contributed the entire manuscript for the Pteridophyta and various specialists have prepared keys, or have aided with determinations or advice. The bulk of the taxonomic treatment, however, represents the author's painstaking effort to weigh everything that has been written about Oregon plants against his own sound taxonomic judgment and his unrivalled knowledge of the area of which he writes. The manual is the culmination of many years of devotion to the flora

of the state, and is based largely upon his own extensive collections, now permanently housed at Willamette University, Salem, Oregon.

From the fine quality of the book, one would not suspect the handicaps under which it was conceived and carried out. Much of the bibliographical work had to be concentrated into infrequent visits to the larger botanical centers, and herbarium study had necessarily to be limited chiefly to the author's personal collections. Dr. Peck's achievement is a credit to his own ability and perseverance, and should greatly encourage in the Pacific Northwest the study of the science to which he has given so many years of his life. Systematic botany in Oregon will henceforth be sharply divided into the period *before* and that *after* the appearance of this book. The author has provided a point of reference and of departure for all future work in the state, an achievement whose value can scarcely be overestimated. This manual will stand as a perpetual challenge to those in the smaller institutions and elsewhere, who imagine themselves unable to carry on productive work because of the lack of facilities or funds, or because of their isolation from the centers of scientific activity. Such obstacles have failed to prevent Dr. Peck from making a brilliantly successful contribution to systematic botany.—L. Constance.

NOTES AND NEWS

Field Work of the Bureau of Plant Industry in Nevada. For years it has seemed desirable to gather up the rapidly vanishing plant lore of the Indians in Nevada. Stimulated by the interest of officials of the Office of Indian Affairs in Nevada and by the University of Nevada, a special project was initiated by the Bureau of Plant Industry which is interested in the plants themselves. From this have ramified various excellent projects. Since a wide knowledge of the state flora was necessary for the basic organization of the other data, the collection and classification of the flora became almost the primary concern. The work has continued for four years, beginning in 1937, and during that time several subsidiary projects have been undertaken.

During the first year there were six groups of collectors, most of them hired merely as collectors, who were sent out in pairs to different sections. There were six other collectors who travelled alone or with an assistant. Among these, under the general direction of W. A. Archer of the Bureau of Plant Industry were: Roy A. Allen, Tim Louise Breene, George E. Franklin, Jr., Frank S. Goodner, Newell F. Hancock, William G. Henning, James R. Henrichs, Philip A. Lehenbauer, Ira LaRivers, Lauritz Lund, William E. McKenzie, Mrs. Edith V. A. Murphey, Loretta R. Miller, Benjamin O. Moore, Norman E. Nichols, Benjamin A. Rives, Harry Sampson and Percy Train. After the first year the collections were made by Dr. Archer and Mr. Train.

The total herbarium collection from the project is 13,798 items, many in duplicate so that much has been left for exchange after the first set was deposited at the University of Nevada and the second in the herbarium of the United States National Arboretum at Washington, D. C. The material is also represented at the Gray Herbarium, New York Botanical Garden, St. Louis Botanical Garden, University of California, Stanford University, Catholic University of America, and the Field Museum of Natural History. The labels which appear on these plants give no indication that the work was done under the supervision of the United States Department of Agriculture so that the material will need to be identified merely by the year and the name of the collectors, which have been indicated above.

Practically all of the identifications have been done by S. F. Blake, C. O. Erlanson, O. M. Freeman, F. R. Fosberg, F. J. Hermann, Robert F. Martin, C. H. Muller and J. R. Swallen all of whom are members of the staff of the Division of Plant Exploration and Introduction. Certain special groups have been identified by experts outside the Division: *Cruciferae* by C. Leo Hitchcock, *Salix* by Carleton R. Ball, *Gilia* by Edgar T. Wherry, *Umbelliferae* (in part) by Mildred Mathias, and *Scrophulariaceae* (in part) by Francis W. Pennell.

More recently, as a result of this work, the Division of Plant Exploration and Introduction has started issuing a mimeographed series known as "Contributions toward a Flora of Nevada." This work is being done by the botanists of the Division in cooperation with the Work Projects Administration of Nevada. It is planned to continue these contributions until all of the plant families of Nevada have been covered. Up to the present there have been about thirty contributions completed, most of them being smaller families, but work is in progress on some of the larger families.—W. Andrew Archer.

Three Alien Plants New to Oregon. The following notes are based on collections made in the vicinity of Portland, Multnomah County, Oregon. The three plants appear not to have been reported hitherto from North America. The specimens cited are deposited in the Gray Herbarium, Harvard University (G), the University of California Herbarium (UC), or the herbarium of the State College of Washington (WS).

Cnidium Monnieri (L.) Cuss. Presumably on ballast, Albina, October 25, 1900, *Suksdorf 2926* (UC, WS). Adventive from Asia, and apparently not persisting here.

Messerschmidia sibirica L. (Determined by Ivan M. Johnston.) On ballast, Peninsula Docks, bank of Willamette River at St. John, July 10, 1936, *Constance 1801* (G, WS). The species was obtained from a similar situation by Suksdorf, many years ago, and is apparently persisting but not spreading.

Lapsana apogonoides Maxim. (Determined by G. L. Stebbins, Jr.) Forming ground cover with *Lysimachia Nummularia* under *Fraxinus* and *Salix* at edge of *Carex* bog, four miles north of Burlington ferry, Sauvies Island, May 28, 1940, *Constance & Beetle 2677* (UC).—L. Constance.

PROCEEDINGS OF THE CALIFORNIA BOTANICAL SOCIETY

March 15, 1941. The annual dinner of the California Botanical Society was held at the Berkeley Women's City Club, Berkeley, on Saturday evening, at 6:30 o'clock. Seventy-three members and their guests were present for the banquet. Professor E. B. Babcock, President, acted as toastmaster, and introduced Dr. D. H. Campbell, Dr. G. J. Peirce, Professor H. E. McMinn, Dr. Ira L. Wiggins, and Mrs. S. B. Parish, who sat at the speakers' table. Professor H. E. McMinn, Professor of Botany, Mills College, Oakland, was the speaker of the evening. The subject of his address was "Botanical Developments in the East Bay Regional Parks." He traced the history of the acquisition and development of the parklands owned by the East Bay Metropolitan Area, emphasizing particularly their botanical and recreational possibilities. The thoroughly enjoyable evening was in charge of the program committee: Dr. G. Ledyard Stebbins, Jr., chairman; Dr. Adriance S. Foster, and Miss Beryl Schreiber, with valuable assistance from Mrs. E. B. Babcock, Mrs. H. L. Mason and Mrs. Lincoln Constance.

April 17, 1941. Third annual "Plants and Specimens" meeting, 2093 Life Sciences Building, University of California, Berkeley, at 7:45 P. M., in charge of Dr. G. Ledyard Stebbins, Jr., and Miss Beryl O. Schreiber. The President, Professor E. B. Babcock, occupied the chair. Short talks about the specimens or exhibits displayed were given as follows: A new tetraploid *Layia*, Dr. David D. Keck; Proteaceae, Miss Alice Eastwood; Vegetation type-mapping by aerial photography, Mr. A. E. Wieslander; The phylogeny of the closed-cone pines, Dr. H. L. Mason; The closed-cone pines of Ano Nuevo Point, Mr. Leo Koch; A new hexaploid *Solanum*, Dr. E. F. Paddock; Artificial production and selection of polyploid grasses for range re-population, Dr. Stebbins. A large number of attractive exhibits, ranging from algae, fungi and lichens to seeds, succulents and unusual cultivated plants were contributed by many exhibitors, including the following: Professor Babcock, Dr. and Mrs. Alan A. Beetle, Mr. and Mrs. Anson F. Blake, Dr. Marion S. Cave, Mr. Yale Dawson, Mr. George B. Furniss, Dr. John W. Gilmore, Dr. Frank Gould, Dr. A. W. Herre, Dr. Robert F. Hoover, Mr. Frank A. Leach, Mr. and Mrs. Forrest McAbee, Miss Elizabeth Morse, Miss Catherine Roberts, Mr. Jack Whitehead and Dr. Ira Wiggins.—L. Constance.

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A WEST AMERICAN JOURNAL OF BOTANY

Contents

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FURTHER STUDIES ON MONOTROPOIDEAE

HERBERT F. COPELAND

This paper continues a series (5, 6, 7, 8, 9), of which the account of *Sarcodes* by Doyel and Goss (12) is to be considered a unit. It records observations on *Pterospora, Hypopitys,* and *Monotropa,* and adds to the previous account of *Hemitomes* (*Newberrya*).

It has been a pleasure to acknowledge from time to time the unstinted cooperation of various institutions and individual correspondents. The following have facilitated the preparation of the present contribution: the Herbarium of the University of California; the Dudley Herbarium of Stanford University; the Herbarium of the California Academy of Sciences; Dr. W. L. Jepson; Mr. Willman Spawn; Dr. W. H. Camp; Dr. P. L. Zimmerman; and the Oregon Biological Supply Company.

PTEROSPORA ANDROMEDEA Nuttall

Pterospora andromedea was described by Nuttall (25) as collected "In Upper Canada, near the Falls of Niagara. Mr. C. Whitlow." There has been essentially no nomenclatorial confusion as to this plant; no segregation of species or varieties has been proposed; Small (28) cites a single obscure synonym. The plant is common in the mountain ranges of western North America; rare eastward to the region of the type locality.

The material studied was collected from time to time at Jonesville, Butte County, California, at an altitude of about five thousand feet. There the plant shares the habitat of *Sarcodes* and *Pleuricospora,* in forests of fir (*Abies concolor*). As compared with its congeners, *Pterospora* emerges from the ground and flowers noticeably later in the season; it is usually in full anthesis late in July.

The shoots come up from globular masses of roots. It is noticeable that whereas they emerge in the neighborhood of dead shoots of the previous year, they are not in immediate contact with such dead shoots, nor at a distance to be measured in centimeters, but a meter or more away. Jepson (19) believes that the plant is monocarpic, and it is probable that he is correct. There is, however, the possibility that the scattered shoots come up from long roots which have emerged from the masses. This is suggested by the behavior of the generality of monotropoid plants, in which the genetic individuals are polycarpic, forming shoots year after year as adventitious buds on the same root system. A positive determination of this matter could be attained only by determining the course of individual roots in a mass of humus, and I have not undertaken it.

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The standard accounts of the gross structure of the shoot, as by Jepson and Small, leave essentially nothing to add. The tall and slender stems, densely glandular, are of a light purplish red color. The greater part of each shoot is a rather lax bracted raceme, usually but not always exhibiting orthodox phyllotaxy. The recurved glandular pedicels bear no bractlets. The five glandular sepals are separate. The five petals form a glabrous sympetalous urceolate corolla, yellowish in color, becoming chartaceous in age. Each of the ten stamens bears two horns on the back of the anther. The globular ovary is belted at the base by a nectary from which ten evenly spaced lobes project between the bases of the filaments. Internally, the ovary is five-chambered below, one-chambered above, filled by massive placentae bearing numerous ovules. The stigma is obscurely five-lobed, the lobes opposite the petals, that is, at the ends of the carpels.

MacDougal has described the anatomy of the vegetative parts. The stem includes a cylinder of bundles so closely packed as almost to be continuous; around this there is a well developed continuous sheath of fibers.

The vascular supply of the flower (pl. 8, fig. 1) enters the receptacle as a cylinder. From this there depart radially, first, five sepal bundles, and then, alternating with them, five petal bundles. There are no gaps above these bundles. Five stamen bundles arise as branches from the upper sides of the petal bundles. Above the departure of the petal bundles the stele breaks up into a ring of ten bundles. Of these, the five which are opposite the sepals bend outward and fork periclinally; the outer branches constitute the supply to the five remaining stamens; the inner ascend the ovary wall in the planes of the septa, and are to be interpreted as fused pairs of lateral bundles of adjacent carpels. The five remaining bundles enter the ovary in the planes of the locules, being the planes of the petals and carpels; each of them is a fused pair of ventral bundles of a single carpel. They branch out into the placentae and disappear. In several features the vascular system just described is peculiar. No other monotropoid plant is known to be without carpel dorsals (though they are not well differentiated from carpel laterals in *Sarcodes*); in none do the placental bundles lie in the planes of the petals. Here it is as though the proper placental bundles had swung outward into the ovary wall, and the carpel dorsals inward, into the placentae. In most plants of the group, the style is supplied by the carpel dorsals, which ascend in the thin bands of tissue between the ridges projecting into the style channel. *Sarcodes* is exceptional in that the placental bundles supply the style, ascending within the ridges. In *Pterospora,* lacking carpel dorsals and having the placentals in a peculiar position, the style is without vascular tissue.

As is known, the anther (pl. 8, figs. 2–7) projects horizontally toward the style from the summit of the filament, and bears two

horns, inserted respectively on the two sides of the insertion of the filament and projecting toward its base. A vascular bundle runs from the summit of the filament to the inward end of the anther; by this it is known that the inward end is distal, the end bearing the horns proximal, the upper side dorsal, and the lower side ventral. There are four parallel horizontal pollen sacs; the dorsal ones are larger than the ventral. A cross section shows the epidermal cells extended into conical points on the dorsal and ventral, but not the lateral, surfaces. Between the epidermis and the tapetum there are some two or three layers of wall cells; near the horns a few of these cells develop reticulate lignified thickenings, as in the endothecium of a typical flowering plant. A similar structure has been reported in *Sarcodes,* and will be reported below in *Monotropa;* it is less extensive in *Pterospora* than in these other genera, being apparently merely a relic structure. The cells of the tapetum become binucleate. The pollen grains are four-grooved.

Dehiscence of the anther begins by two vertical slits, each of which crosses the proximal ends of the two pollen sacs of one lobe of the anther. Formation of these slits amounts to the same thing as the dehiscence of the anthers of *Sarcodes* or *Monotropsis,* being, as I take it, the typical dehiscence of the anthers of Ericales. Subsequently two secondary slits develop from the middles and at right angles to the primary ones, that is, in the plane between the two pollen sacs of each lobe of the anther. By a general shrivelling of the walls of the anther, accompanied by growth of the connective, these secondary slits gape widely; it is through them that most of the pollen escapes. Drude's (13) figure of the fully dehisced anther is accurate, though it gives a false impression that the connective becomes torn in a horizontal plane from proximal to distal.

The internal surface of the ovary wall is covered by two layers of well developed fiber-like cells.

A complete series of stages of the development of the seed has not been seen, and there is nothing to add to my earlier notes (4). The embryogeny appears to be altogether typical of the group. The integument is of two layers of cells. The wing on the seed is of two layers of cells. It commences to form, by proliferation of the epidermis of the integument at the chalazal end, before the embryo sac is fully developed.

Hypopitys Monotropa Crantz

Only two species of monotropoid plants were known to Linnaeus (23). One, known in English as the pine-sap, occurs on all continents of the north temperate zone; the other, the Indian pipe, occurs in North America and eastern Asia, but not in western Asia and Europe. The oldest Latin designation of the pine-sap seems to be *Orobanche quae hypopithis dici potest,* of Bauhin (1671). It is of course no *Orobanche;* Tournefort (1706)

gave it as name the adjective *Orobanchoides;* Dillenius (1719) took up the substantive designation recorded by Bauhin, as *Hypopitys.* The Indian pipe, first recorded by Plukenet (1671) under *Orobanche,* was named *Monotropa* by Gronovius (about 1740). Linnaeus included both species in one genus, for which he used the name *Monotropa,* the species becoming respectively *M. Hypopithys* and *M. uniflora.* The breach of priority as to the generic name was immediately protested by Hill (16): "Linnaeus takes away its received name *hypopitys* and calls it *monotropa.*" Because he was the first after 1753 to use *Hypopitys* as the name of a genus, Hill is cited as authority for it; this in spite of the facts, that he did not originate it, and that he did not use binomials and cannot be cited as authority for any of the species. Binomials under *Hypopitys*[1] were first made by Crantz (10), the pine-sap becoming *H. Monotropa* and the Indian pipe *H. uniflora.*

Inasmuch as the first post-Linnaean authors gave to *Hypopitys* exactly the extent which Linnaeus had given to *Monotropa,* it might be held that the two names are exact synonyms, and that *Hypopitys* is not available as the name of any genus. On the other hand, the pre-Linnaean history shows that the two names are based on different types, and that if the pine-sap is placed in a different genus from the Indian pipe its name is *Hypopitys.* Such in effect was the conclusion of the pre-type-system authors Nuttall (25) and Bentham and Hooker (1); such was the conclusion of Small (27), who made the combination *Hypopithys Hypopithys.* Repeating binomials being excluded by our rules, we must accept the first specific epithet published after 1753; this yields, as has been shown, the combination *Hypopitys Monotropa.* We might be glad to reject this combination as a matter of taste; it has gone almost completely unaccepted since its original publication; but the rules are designed to spare us the responsibility for a choice.

I follow Kamienski (21) and Domin (11; this work has been a most valuable guide to the history and literature) in recognizing only one species of *Hypopitys.* There are considerable variations, and Small (28) has recognized five species in North America alone; but these variations seem so inconstant as to make the recognition even of varieties a critical matter.

The available material preserved in liquid has included several roots, stems, and flowers collected by Dr. W. H. Camp, in Oregon, Ohio, and Tennessee, and two shoots with nearly ripe fruit collected by Mr. Willman Spawn in Rock Creek Park, Washington, D. C., in July of 1938.

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[1] Variations in the spelling will be noted. I have not consulted the pre-Linnaean publications. Linnaeus wrote *Hypopithys,* Hill and Crantz *Hypopitys.* These are mere variant spellings; but we are forbidden by rule to meddle with them. In using the word as a specific epithet, we must follow Linnaeus; in using it as a generic name, we must follow Hill.

Nothing is here added to knowledge of the gross structure. The shoots originate endogenously in roots, a mass of which constitutes the permanent organ of the plant. Domin, after a long discussion of the literature, concludes that the underground structures are not true roots, but an axis not differentiated as root or stem, to be called the *Prokaulom* (anglicizable as procaulon). I have not examined these structures, but the conclusion is inescapable, from Kamienski's (20, 21) description and from what is known of the other monotropoid plants, that Domin is mistaken. As Christoph (3) has shown, the occasional more or less complete suppression of some of the characters of roots—the cap and endogenous branching—depends on the presence of mycorrhiza. The same effacement of character appears in the roots of other plants when they are beset with mycorrhiza.

The shoot is usually yellowish and more or less pubescent. The upper part of it constitutes a bracted raceme. When it emerges from the ground, the raceme is bent to one side, and the buds or flowers are crowded and more or less pendant; later the axis and pedicels become erect and the flowers or fruits become separated. At its maximum the shoot is rarely twenty-five centimeters tall.

The lateral flowers (pl. 8, fig. 8) stand in the axils of bracts whose margins vary from entire to lacerate. There are no bractlets; four sepals, a lower pair placed laterally and an upper pair placed dorsally and ventrally with regard to the flower; four separate petals with saccate bases, alternating with the sepals; eight stamens; a nectary with eight horn-like lobes arranged in pairs which clasp the bases of the petalad stamens; a pistil, the ovary four-chambered below, one-chambered above, the stigma obscurely lobed, the lobes opposite the petals. Variations in the proportions of ovary and style, as well as in color, pubescence, and the indentation of the margins of the bracts, have been utilized for subdivision of the species.

Older accounts definitely described the terminal flower as pentamerous. I have not found such a flower. I believe that in the few shoots preserved in liquid which I have examined the terminal flower has been suppressed. The highest flower has been tetramerous, the pedicel embraced by two bracts instead of one (evidently as a result of shortening of the last internode, the one above the insertion of the flower), the lower pair of sepals somewhat removed from the flower.

Domin cites many authors who have disagreed as to whether the outer envelope of the flower is really a calyx, and its segments sepals: Eichler is the chief authority in the affirmative, Baillon in the negative. He quotes observations of Irmisch (17) and Wydler (30) and gives his own, to the effect (a) that the upper pair of leaves of this envelope are, one or both of them, often suppressed; (b) that the lower pair are often somewhat withdrawn from the base of the flower; (c) that these leaves, espe-

cially the lower pair, often have buds in their axils. He concludes that they are not true sepals, but elevated bractlets in process of conversion into sepals. It seems to me unreasonable to recognize a calyx in course of coming into existence in any group as advanced as Ericales: rather, any irregularities are to be interpreted as matters of degeneration. Since *Allotropa* is the only positively asepalous genus of the monotropoid group; since only *Monotropsis* and sometimes *Allotropa* have definite bractlets; we may interpret the facts assembled by Domin in some such fashion as this: the structures of *Hypopitys* now under consideration are positively sepals; they are affected by a tendency to degeneration; it is possible that a tendency to produce bractlets, almost completely extinct in this genus, retains enough strength to affect the course of the degeneration.

Kamienski has accounted in full for the anatomy of the vegetative parts; I have here only to describe the vascular supply to the flower. One bundle from the circle in the stem turns outward. It becomes flattened tangentially and presently splits into three branches, of which the middle one supplies the bract while the two on the sides swing together and unite as a cylinder ascending the pedicel. All this is quite the same as in the genera previously studied. The cylinder of vascular tissue ascending the pedicel becomes compressed in the dorso-ventral plane, so as to approximate a four-sided prism (pl. 9, fig. 10). From each of its faces there departs a sepal trace, leaving a small gap or none. The traces to the lateral sepals depart at a much lower level than those to the dorsal and ventral sepals; this is in harmony with Domin's observations as to the relative positions of the sepals. The petal bundles emerge as broad bands from the angles of the prism; each promptly forks into three, of which the one in the middle is the smallest and descends under the sac of the petal, while the larger lateral ones ascend past the sac. The petalad stamen bundles are not fused with the petal bundles, but are closely associated with them; each originates as a pair of bundles at the sides of a petal bundle, the pair drawing together and uniting above the petal bundle. The sepalad stamen bundles emerge at the edges of the siphonostele as it breaks up. The carpel dorsals, well developed in the ovary walls and style, are only with difficulty traced to their origin; the feebly developed provascular strands that lead into them seem to originate typically as paired strands beside, above, and resembling the petalad stamen bundles. Foster (15) has recently quoted Gregoire to the effect that floral

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Explanation of the Figures. Plate 8.

Plate 8. Pterospora andromedea. Fig. 1. Model of the vascular system in the receptacle × 50. *Ca,* sepal bundles; *Co,* petal bundles; *St,* stamen bundles; *Cl,* carpel laterals; *Pl,* placental bundles. Figs. 2, 3. Juvenile stamens, × 10. Fig. 4. Longitudinal section of juvenile stamen, × 50. Fig. 5. Cross section of juvenile stamen at the plane marked *x* in fig. 4, × 50. Fig. 6. Area marked *x* in fig. 5, × 400. Fig. 7. Cross section of dehisced stamen, × 50. Hypopitys monotropa. Fig. 8. Old flower in which the fruit is nearly ripe, × 5.

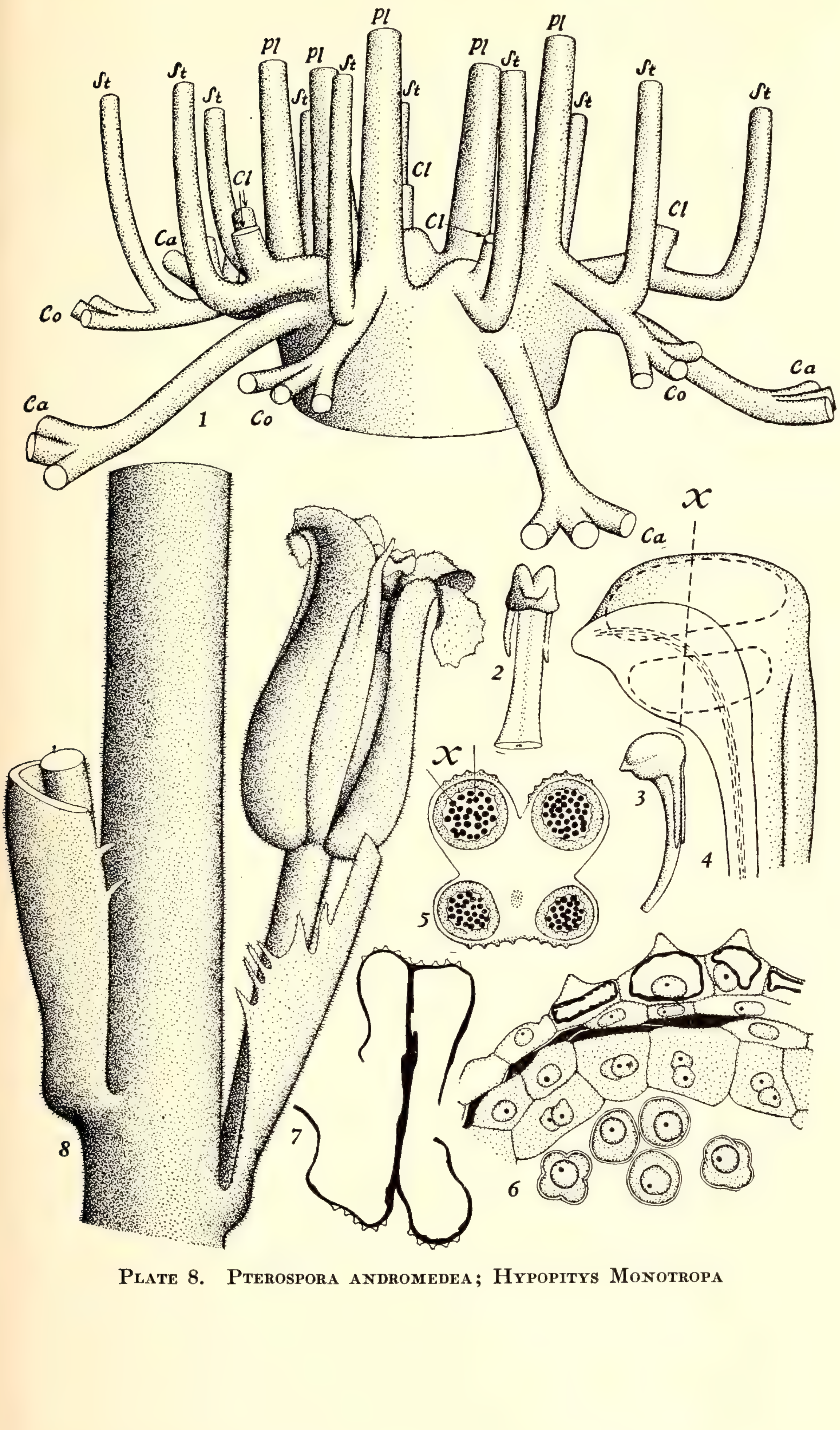

PLATE 8. PTEROSPORA ANDROMEDEA; HYPOPITYS MONOTROPA

leaves are distinguished from vegetative leaves by acropetal development of the vascular supply. The carpel dorsals of *Hypopitys* (and likewise, as will be seen, of *Monotropa* and *Hemitomes*) constitute an exception to this principle. The breaking up of the siphonostele finally yields one bundle to each lateral placenta, and two each to the dorsal and ventral placentae. This seems to be an outcome of the bilateral character of the whole vascular system. It is as though the ventral bundles of adjacent carpels were fused at the sides of the flower, but not at the front and back.

It is regretted that no anatomical study has been made of young stamens. The anther opens by two vertical slits at the outer, presumably proximal, end; these slits meet above, separating a small outer valve from a large inner one; and soon the valves liberate the pollen by swinging widely apart. Young stages and old ones (pl. 9, figs. 11, 12) respectively agree exactly with corresponding stages of *Pityopus* as illustrated by Eastwood (14). It is particularly regretted that the position of the pollen sacs was not ascertained; though it may be presumed that there are four in each anther, lying horizontally, each slit of the anther crossing the ends of two of them. The pollen grains are two-grooved.

The fruit is a capsule, its inner surface covered by a single layer of elongate cells not distinguished by staining reactions.

The development of the seed has been described in detail by Koch (22). I have seen only one stage, conforming well to Koch's account, and so beautifully clear that I could not refrain from drawing it (pl. 9, fig. 9).

Monotropa uniflora L.

Of the name of this genus and species enough has been said above. The genus is apparently monotypic; no variation even of varietal rank is recognized as occurring within the United States. *Monotropa coccinea* Zuccarini, of Mexico and Central America, and *M. australis* Andres, of Colombia, were treated as varieties by Domin.

The available material preserved in liquid has included six collections, as follows: (1) Three shoots purchased some years ago from the New York Biological Supply Company, as a museum specimen, without collection data. (2) Three shoots presented by the Oregon Biological Supply Company; collected by R. E. Griffin, Bullrun, Oregon, July 11, 1939. The fluid preserves the white color of the plants, and makes specimens excellent for museum use rather than for sectioning. (3) A number of shoots presented by the Herbarium of the University of California, without collection data. (4) One shoot, with roots, furnished by Mr. Willman Spawn; collected in Rock Creek Park, Washington, D. C., July, 1938. (5) One shoot, with roots, furnished by Dr. P. W. Zimmerman; collected in the arboretum of the Boyce Thompson Institute for Plant Research, New York, summer, 1939.

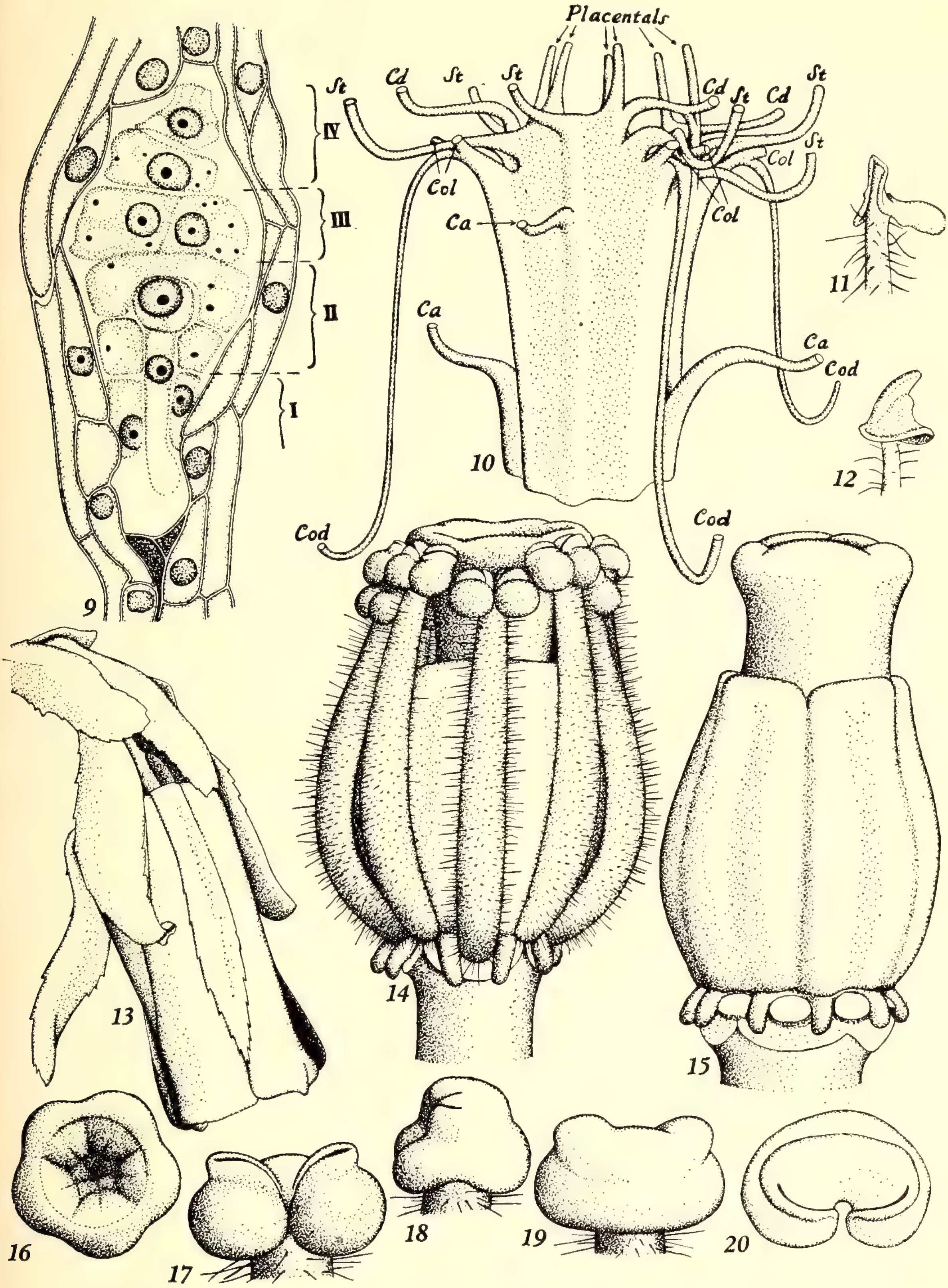

Plate 9. Hypopitys Monotropa. Fig. 9. Longitudinal section of nearly ripe seed × 400. The endosperm, at a certain early stage, is four-celled; the Roman numerals I–IV indicate the derivatives of these cells. Fig. 10. Model of the vascular system in the receptacle × 12.5: *Ca,* sepal bundles; *Cod,* petal dorsals; *Col,* petal laterals; *St,* stamen bundles; *Cd,* carpel dorsals. Figs. 11, 12. Dehisced anthers × 10. Monotropa uniflora. Fig. 13. Flower × 2.5. Fig. 14. Flower with perianth removed × 5. Fig. 15. Pistil × 5. Fig. 16. Stigma × 5. Figs. 17–20. Anthers × 10.

(6) Roots, shoots, flowers and fruits furnished by Dr. W. H. Camp; collected in central New York State at various times.

As is well known, the erect shoots are in life white, like paraffin (the austral races mentioned above are distinguished by red color); dried, or placed in most preservatives, they turn black. The stem is clad with spiral scales; study of a single example showed the spiral to be orthodox. The solitary flower (pl. 9, fig. 13) is terminal on the recurved summit of the stem. Domin has quoted many conflicting authorities as to whether or not sepals are present. I find that a varying number of scales may project past the base of the flower. Of these, sometimes none and sometimes one is inserted so immediately below the petals that it can be regarded as a sepal. It is not particularly different from the leaves, and I have not found more than one. The five separate petals overlap at the margins so as to form a campanulate corolla about fifteen millimeters long. Each petal is saccate at the base and truncate at the apex, sometimes with an apiculation. There are ten stamens, manifestly in two whorls, the lower opposite the petals. The densely pubescent filaments are curved inward and bear the subglobular anthers pressed against the lower side of the stigma (pl. 9, fig. 14). The ovary is belted at the base by a ten-lobed nectary; the lobes are cylindrical; they are obscurely but perceptibly paired, clasping the bases of the petalad stamens. The ovary is ovoid, marked by five deep longitudinal grooves opposite the petals, that is, in the median planes of the carpels; and by five shallow grooves between them where the carpels meet (pl. 9, fig. 15). A shallow circular depression at the summit of the ovary is filled by the base of the short, stout, obconical style. The stigma is five-lobed, the lobes opposite the petals and surrounding an unusually large crater-like depression which leads into the style passage. The depression is lined by five masses of tissue which stand above the grooves, not the ridges, in the style passage. The surfaces of the five masses of tissue are more or less wrinkled, and the grooves in the style passage are obscurely continued upward upon them to some distance (pl. 9, fig. 16).

The stem resembles in its anatomy that of *Pterospora* rather than those of *Monotropsis* and *Hypopitys.* It shows in cross section a ring of separate strands of xylem and phloem (in most specimens seriously shattered by shrinkage, apparently during fixation, a difficulty commonly encountered also in *Sarcodes* and *Pterospora*). Around the cylinder of bundles there is a continuous sheath of pericyclic cells with thinly lignified walls, being imperfectly developed fibers.

At the summit of the stem the sheath disappears. Exactly ten bundles enter the receptacle (pl. 10, fig. 25). Each of the five lying in the planes of the petals breaks up, typically, into five. Of these, the middle one is the petal bundle; it forks further into three, a small petal dorsal which follows the contour of the sac, and two larger petal laterals which ascend past it. The behavior

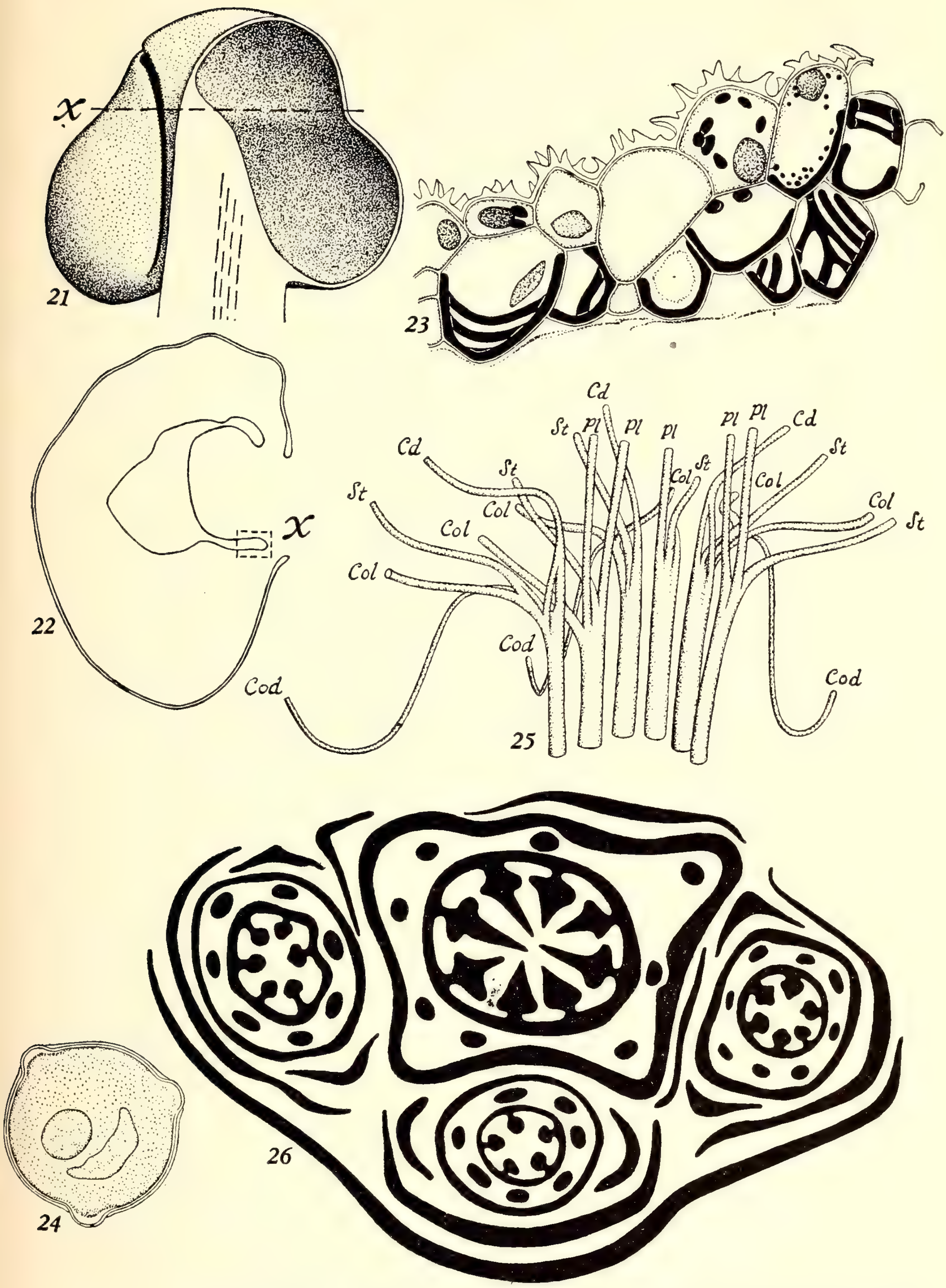

Plate 10. Monotropa uniflora. Fig. 21. Longitudinal section of anther $\times 25$. Fig. 22. Cross section of anther at the plane indicated by x in fig. 21 $\times 25$. Fig. 23. Area marked X in fig. 22 $\times 400$. Fig. 24. Pollen grain $\times 900$. Fig. 25. Model of half of the vascular system in the receptacle $\times 12.5$: *Cod,* petal dorsals; *Col,* petal laterals; *St,* stamen bundles; *Cd,* carpel dorsals; *Pl,* placental bundles. Hemitomes congestum. Fig. 26. Cross section of primary flower with three secondary flowers in the axils of the sepals $\times 10$.

of these petal bundles is quite the same as in *Monotropsis, Hypopitys,* and *Pityopus.* The two bundles adjacent to the petal bundle unite above it to form a petalad stamen bundle, and the two marginal branches unite to form a carpel dorsal which is traced with difficulty here at its origin. As to the five bundles which enter the receptacle between the planes of the petals, each of these forks into three: the middle one supplies a stamen of the upper whorl; the lateral ones enter the placentae, being ventral bundles of adjacent carpels. The figure shows minor deviations from the assumed typical structure as just described: one of the petal lateral bundles does not originate from a proper petal bundle; one of the placental bundles is suppressed. The carpel dorsals enter the style and ascend it for some distance, but they are there poorly developed.

If the anther (pl. 9, figs. 17–20; pl. 10, figs. 21–23) is correctly understood, the outer end is proximal, the inner distal, the upper side dorsal and the lower ventral. At anthesis it includes a single chamber. Apparently (these points were regrettably not established) there are in the juvenile anther four horizontal pollen sacs, of which the ventral pair are much the larger. Dehiscence is through two curving slits at the proximal end; in dried material, and doubtless in life, these slits flare open as gaping pores. Along the margins of the slits the anther walls, elsewhere of one layer of collapsed cells, are of two layers, the walls of the inner layer bearing reticulate lignified thickenings as in a normal endothecium (pl. 10, fig. 23). Jepson states that the slits eventually meet, so as to convert the anther wall into two valves. This is not true in such fruiting material as I have seen; on the contrary, the pores retain their individuality until the plant dies and decays. The pollen grains (pl. 10, fig. 24) are three-grooved. The tube nucleus stains poorly and becomes distorted; the generative nucleus remains globular and deeply staining, and is surrounded by a clear space (not shown in the figure), the generative cell.

The inner surface of the ovary wall is covered by a single layer of somewhat elongate cells not distinguished by staining reactions.

Of the stages in the development of seed, we know only the structure of the mature ovule. It was described and figured long since by Campbell (2) quite as in *Hypopitys.*[2]

[2] Since the above was written Dr. Zimmerman has had the kindness to send a beautiful collection of fruiting material made in the Arboretum of the Boyce Thompson Institute in late summer of 1940. The seeds are much as in *Allotropa;* they are elongate, having a tail at each end; the embryo, borne on a suspensor, is usually of two cells; the endosperm has a haustorium at each end. It is now known that haustoria are produced on the endosperm in *Sarcodes, Allotropa, Monotropa,* and probably (to reinterpret a former observation) in *Monotropsis;* and that they are not produced in *Hypopitys* and *Pleuricospora.* I suppose that the absence of haustoria in these two genera is a result of parallel evolution and that the classification given at the end of this paper, in which *Hypopitys* falls near *Monotropa* and *Monotropsis* and far from *Pleuriscospora,* may stand.

Hemitomes congestum Gray

Under the name of *Newberrya,* I have given a partial description of this rather uncommon plant of the Pacific Coast of North America, and have quoted from Jepson; but Jepson's description and mine require extension and amendment.

The original generic name *Hemitomes* was rejected by Torrey (29) as inappropriate; and the rejection was maintained by Small (28) on account of the priority of *Hemitomus* L'Her. Torrey's objection is of no standing in modern nomenclature; and Small's is disposed of by the rule (26) "When the difference between two generic names lies in the termination, these names must be regarded as distinct, even though differing by one letter only." Small recognized five species. Jepson has reduced three of these, whose type localities are in California, to synonymy with the type species. With this I fully agree, and I add the one which Jepson omitted as outside his area. I am glad to remark that Professor John Davidson has tended to support this action, in a paper read at Seattle in June, 1936; and that Dr. W. H. Camp has done so in private correspondence. The synonymy, then, is as follows:

Hemitomes congestum A. Gray, Pacif. Rail. Rep. 6: 80. 1857. *Newberrya congesta* Torr. in Gray, Bot. Calif. 1: 464. 1876. *N. spicata* A. Gray, Proc. Am. Acad. 15: 44. 1879. *Hemitomes pumilum* Greene, Erythea 2: 121. 1894. *Newberrya subterranea* Eastw., Proc. Calif. Acad. Sci., ser. 3, 1: 80. 1897. *Hemitomes spicatum* Heller, Cat. No. Amer. Pl. 5. 1898. *H. subterraneum* Heller, *op. cit. Newberrya longiloba* Small, No. Amer. Fl. 29: 18. 1914. *N. pumila* Small, *op. cit.*

The Herbarium of the University of California has a photograph of the type of *Newberrya spicata,* and a photograph and a duplicate of *Suksdorf 2168,* the type of *N. longiloba.* I have been particularly helped by Dr. Jepson, who loaned a specimen collected by W. G. Wright, the type of *H. pumilum.* Two collections preserved in liquid have been available: (1) One shoot without roots, furnished by Dr. L. R. Abrams, who collected it in the California State Redwood Park, Santa Cruz County, June 14, 1934. (2) Several shoots and roots collected by Dr. W. H. Camp at Sol Duc Hot Springs, in the Olympic Peninsula, Washington, August 5, 1932.

Shoots, arising endogenously from roots, vary in height, the flowers being borne approximately at ground level; they expand in ascending, when well developed exceeding two centimeters in diameter at the base of the inflorescence. The inflorescence is essentially a bracted spike, often so brief and compact as to be accounted a head; in Abrams' specimen the phyllotaxy, both of the leaves below the inflorescence and of the flowers, is orthodox, the apparent divergence being 3/8 or 5/13. Depauperate shoots may bear a single flower; on the other hand, vigorous shoots may bear axillary branches with one or more flowers, and may develop

secondary flowers in the axils of the sepals of the primary flowers. This behavior was noted on dissection of the type of *H. pumilum;* of Abrams' specimen; and of a specimen by C. A. Reed in the Herbarium of the California Academy of Sciences. Jepson's words, "Inflorescence . . . composed of short 2- to 5-flowered spikelets" imply that it is normal; but I find it only in a minority of the specimens; I do not find it in Camp's preserved material. The flowers (pl. 11, fig. 27) are practically always tetramerous; the four sepals are oriented as in *Hypopitys* and *Pleuricospora,* dorsally, ventrally, and laterally, the dorsal and ventral sepals being not infrequently suppressed. The sympetalous corolla is variable in length, from less than one centimeter to nearly two centimeters long. The four lobes alternate with the sepals, and are separate to a depth of more or less than one-third the total length of the corolla. The dried corolla is very fragile, and it is hard to be certain as to how deep the sinuses extend. *Newberrya longiloba* was distinguished by particularly deep sinuses, but I do not find these in our duplicate of the type. Indentation of the corolla lobes is variable; the retuse apex mentioned in my former account was merely the character of an individual. Stamens are normally eight, anthers dehiscing by two lengthwise slits on the outside; lobes of the nectary moderately prominent, evenly spaced; carpels eight, alternating with the perianth parts and stamens, so that the parietal placentae, and the lobes of the stigma, standing above them, are opposite the stamens and perianth parts.

Secondary flowers are usually in the axils of the lateral sepals, but may appear also in the axils of dorsal and ventral sepals (pl. 10, fig. 26). In the cluster figured, there is a second pair of scales, like sepals, above the lateral secondary flowers, as if the scales subtending these were bractlets: *Hemitomes* would have afforded Domin even better evidence than did *Hypopitys,* that the outer floral envelope is no true calyx. But what is the scale in whose axil is the dorsal secondary flower? And what is the scale on the ventral side of the primary flower, if not a sepal? I regard the scales subtending the lateral secondary flowers as sepals; and the scales above these flowers as a secondary pair of sepals, anomalously developed in connection with the anomaly of buds in the axils of the primary pair. The secondary flowers ordinarily have parts in smaller numbers than the primary ones, as two sepals, seven or six stamens, seven, six, or five carpels. They are later in development than the primary flowers.

The vascular system in the stem, as reconstructed from sections of Abrams' specimen (pl. 11, fig. 30), is a cylinder interrupted by very large leaf gaps; as there are no other gaps than these, and as the vascular tissue runs in broad oblique bands rather than in slender vertical bundles, it may be regarded as a siphonostele. The leaf traces, emerging at the bases of the gaps, fork into three as they enter the scales. Flower traces are not at all united with the traces to the subtending scales; the supply to

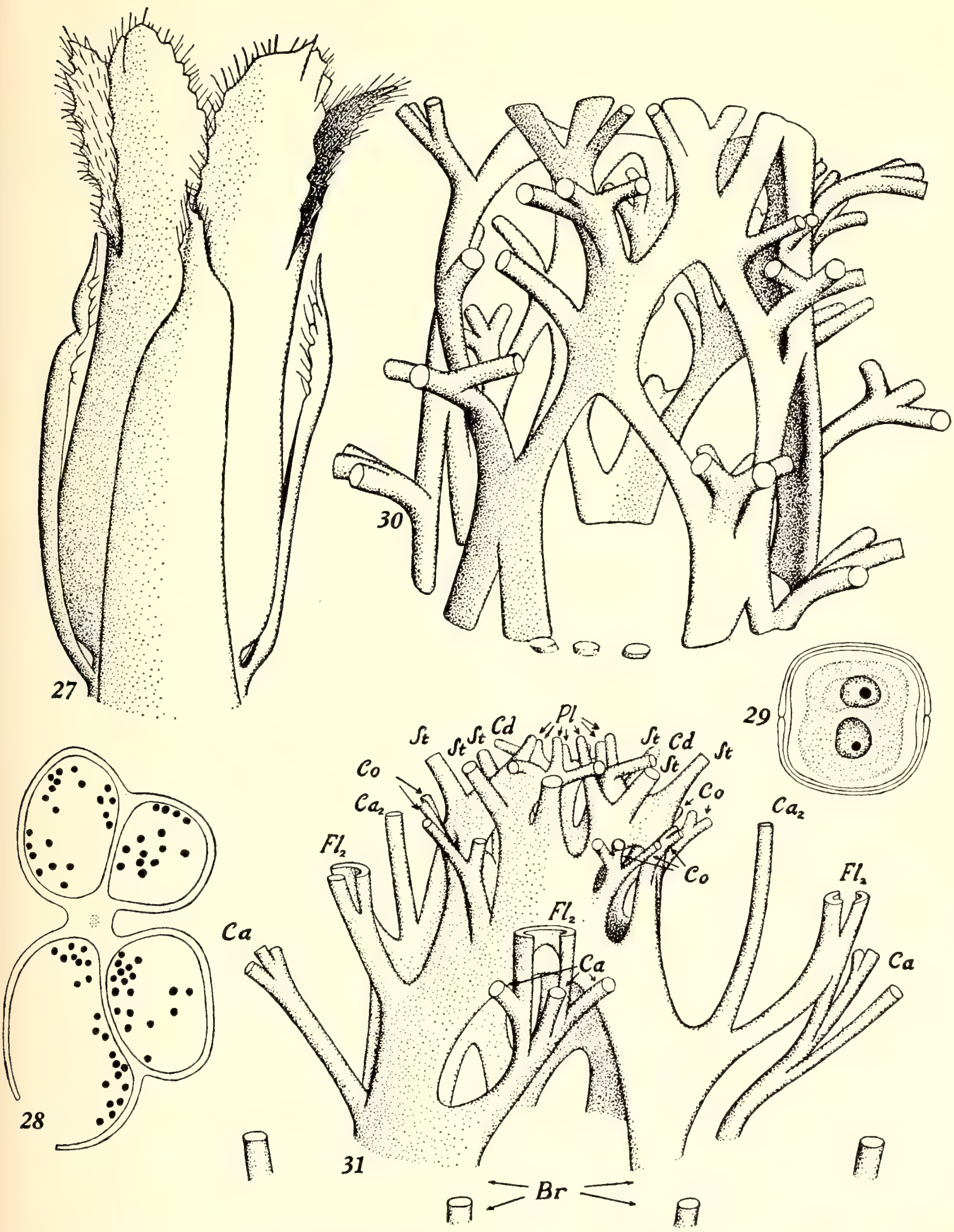

PLATE 11. HEMITOMES CONGESTUM. FIG. 27. Flower $\times 5$. FIG. 28. Cross section of juvenile stamen $\times 50$. FIG. 29. Pollen grain $\times 900$. FIG. 30. Model of the vascular system in the stem $\times 5$. FIG. 31. Model of the vascular system of the cluster of flowers shown in fig. 26 $\times 15$: *Br,* bundles to the bract; *Ca,* sepal bundles; Fl_2, supplies to secondary flowers; Ca_2, secondary sepal bundles; *Co,* petal bundles; *St,* stamen bundles; *Cd,* carpel dorsals; *Pl,* placental bundles.

each flower consists of two bundles springing from the sides of the gap above one of the upper leaves.

The figure of the vascular system of a primary flower with its attached secondary flowers (pl. 11, fig. 31) was constructed from a series of sections of Abrams' specimen, one of which yielded the diagram (pl. 10, fig. 26). The two bundles of the flower trace approach one another, become flattened, and unite as a siphonostele. Before this union is complete, four sepal traces emerge as single bundles above which there are large gaps. It seems that a secondary flower is typically supplied, like a primary flower, by two bundles springing from the sides of the gap left by the supply to the subtending leaf, which is in this case a sepal. Actually, we find that the secondary flower placed on the left in the figures is supplied as just described; the one on the right is partially so supplied, and partially from the sepal trace; the third, the dorsal secondary flower, is supplied entirely from the trace to the subtending sepal. The single bundles to the secondary sepals of the primary flower arise next to two of the secondary flower bundles. Each petal is supplied by two bundles which leave a single gap in the stele. Beyond these the stele emits three whorls each of eight bundles: stamen bundles, one opposite each perianth segment, all apparently in one whorl, not at all associated with the petal bundles; carpel dorsals, alternating with the stamen bundles, very poorly developed at the base, so that formerly I failed to discover their origin; and placental bundles, opposite the stamen bundles.

Juvenile stamens were found in the secondary flowers. The anther is borne vertically on the summit of the filament and includes four parallel vertical pollen sacs, of which the two on the dorsal side are much the larger. (I was formerly mistaken in making the ventral sacs the larger.) Dehiscence is through vertical slits on the dorsal sides of the dorsal sacs; the wall between the two pollen sacs of each lobe breaks down, and the whole outer wall swings around to the ventral side of the anther as a broad valve.

The cells of the inner surface of the ovary wall are not differentiated except perhaps by smaller size.

No new observations have been made upon the development of seeds; all that is known is that the ovules are essentially like those of *Hypopitys* and other members of the group.

Discussion

In concluding the previous paper of this series, I put forward a tentative scheme of classification of the plants construed as constituting the subfamily Monotropoideae of family Ericaceae:

Tribe Pterosporeae: *Pterospora, Sarcodes, Allotropa.*

Tribe Monotropeae: *Monotropsis, Hypopitys, Pityopus, Monotropa, Monotropastrum, Wirtgenia?*

Tribe Pleuricosporeae: *Pleuricospora, Newberrya, Cheilotheca?*

Observations have now been extended to all of the above-named genera which are native in North America. Not a few of my previous statements have been found to require correction. A summary of the observations constitutes a formidably extensive table (Table 1). The data there assembled enable one to construct a tentative phylogenetic tree (text fig. 1) and to reconsider the proposed scheme of classification.

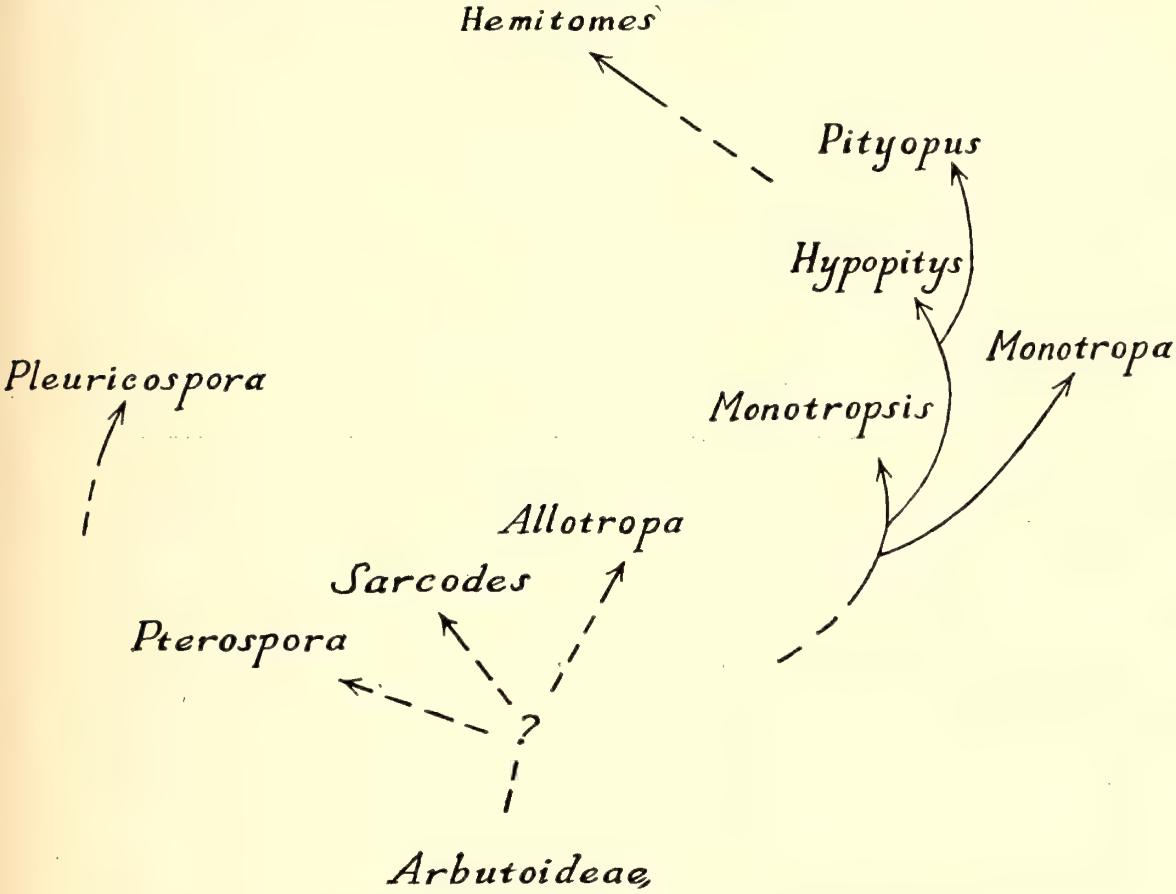

FIG. 1. Apparent phylogeny of the Monotropoideae.

Pterospora, Sarcodes, and *Allotropa* continue to appear more primitive than the other genera. The primitive features are tall and erect habit; bright coloration; axile placentation in the lower part of the ovary; evenly spaced lobes of the nectary; corolla sympetalous, urceolate (in *Pterospora* and *Sarcodes*); bractlets present (in some specimens of *Allotropa* only); anthers horned (in *Pterospora* only); anthers not permanently erect. The only single characters which separate these genera as a group from the others are the habit and the coloration; but the combination of characters, lobes of the nectary not paired and anthers not erect, is also distinctive. In all this, there is nothing to raise doubt as to the status of the tribe Pterosporeae as a natural group; often a primitive group can be distinguished from several derived groups taken together only by a combination of negative characters. Doubt appears when, on the other hand, we compare these genera with the supposed ancestral group Arbutoideae. The primitive characters of the Pterosporeae are in large part merely the characters of Arbutoideae; only saprophytism and the habit

Table 1. Characters of North American Monotropoideae

Genus	Habit	Color	Flower	Placentation	Lobing of stigma	Fruit	Inner surface of ovary	Stele in stem
Pterospora . .	tall, erect	pale purplish red	5-merous sympetalous	axile below, parietal above	obscure; opposite petals	loculicidal capsule	two layers of fiber-like cells	ring of bundles with lignified sheath
Sarcodes	stout, erect, moderately tall	red	5-merous sympetalous	axile below, parietal above	opposite petals	capsule opening about base of style	scant differentiation near line of dehiscence	cylinder without sheath
Allotropa . . .	tall, erect	white with red stripes	5-merous choripetalous asepalous	axile below, parietal above	opposite petals	loculicidal capsule	one layer of fiber-like cells	cylinder with sheath
Monotropsis .	slender, rather short, declined when young	white ?	5-merous sympetalous	parietal	obscure	berry	one layer of non-lignified elongate cells	ring of bundles, no sheath
Hypopitys . . .	slender, rather short, declined when young	white to yellow	4-merous choripetalous	axile below, parietal above	opposite petals	loculicidal capsule	one layer of non-lignified elongate cells	ring of bundles, no sheath
Pityopus	slender, rather short, erect	white	4-merous choripetalous	parietal	obscure	berry?	undifferentiated	cylinder without sheath
Monotropa . .	slender, rather short, declined when young	white	5-merous choripetalous	axile below, parietal above	opposite petals	loculicidal capsule	one layer of non-lignified elongate cells	ring of bundles with lignified sheath
Pleuricospora	small, erect, flowering at ground level	white	4-merous choripetalous	parietal	opposite sepals	berry	undifferentiated	cylinder without sheath
Hemitomes . .	small, erect, flowering at ground level	pale yellow-pink	4-merous sympetalous	parietal	opposite sepals, petals, and stamens	berry?	undifferentiated	cylinder without sheath

TABLE 1, CONTINUED

Genus	Stele in pedicel and receptacle	Stamen bundles	Ovary wall bundles	Placentals	Style bundles	Anthers and pollen sacs	Dehiscence of anthers	Number of grooves on pollen grains
Pterospora . .	cylinder	outer whorl fused to petal bundles, inner to carpel laterals	carpel laterals	in planes of petals; each is fused ventrals of same carpel	none	horizontal; dorsal sacs are longer	(1) proximal ends of lobes; (2) lengthwise of sides of lobes	4
Sarcodes	ring of about 5 bundles	outer whorl fused to petal bundles, inner to ovary wall bundles	numerous; no definite carpel dorsals	in planes of sepals; each is fused ventrals of adjacent carpels	placentals	inverted; dorsal sacs are longer	proximal ends of lobes	4
Allotropa . . .	cylinder	outer whorl fused to petal bundles, inner free	carpel dorsals	in planes of sepals; each is fused ventrals of adjacent carpels	carpel dorsals	erect when young, inverted when mature; dorsal and ventral sacs subequal	proximal ends of lobes	3
Monotropsis .	about 4 partially fused bundles	two whorls, free of other bundles	carpel dorsals	in planes of sepals; each is fused ventrals of adjacent carpels	carpel dorsals	horizontal when young, mature inverted; dorsal and ventral sacs subequal	proximal ends of lobes	2
Hypopitys . . .	flattened cylinder	two whorls, free of other bundles	carpel dorsals	in planes of sepals; fused or unfused ventrals of adjacent carpels	carpel dorsals	horizontal, ventrals sacs longer?	proximal ends of lobes?	2

TABLE 1, CONCLUDED

Genus	Stele in pedicel and receptacle	Stamen bundles	Ovary wall bundles	Placentals	Style bundles	Anthers and pollen sacs	Dehiscence of anthers	Number of grooves on pollen grains
Pityopus	cylinder	two whorls, inner connected to pistil bundles	8 carpel dorsals alternating with stamens	8, in planes of stamens	carpel dorsals	horizontal, ventral sacs longer?	proximal ends of lobes?	2
Monotropa	ring of ten bundles	two whorls, free of other bundles	carpel dorsals	in planes of sepals; unfused ventrals of adjacent carpels	carpel dorsals	horizontal, ventral sacs longer?	proximal ends of lobes?	3
Pleuricospora	cylinder	outer whorl fused to petal bundles, inner free	carpel dorsals	in planes of sepals; each is fused ventrals of adjacent carpels	carpel dorsals	vertical, dorsal and ventral sacs subequal	lengthwise of sides of lobes	4
Hemitomes	broken cylinder	apparently one whorl; free of other bundles	8 carpels dorsals alternating with stamens	8, in planes of stamens	carpel dorsals	apparently vertical, dorsal sacs broader	dorsal sides of dorsal sacs	2

which is presumably a result of it are distinctive. Furthermore, the Pterosporeae are notably heterogeneous in anatomy of stem and receptacle, and in corolla, anther, fruit, and seed. I would allow the tribe to stand as a tentative group, and would expect studies of the Arbutoideae to afford evidence as to whether or not it is a natural group, having one origin among Arbutoideae.

The Monotropeae, though differing among themselves in various features, yet exhibit marks of unity; the saccate bases of the petals and the paired lobes of the nectary are associated with a peculiar and definite structure of the vascular supply to the petal. This is safely a natural group. In the corolla, *Monotropsis* is the most primitive of the genera; but in the ovary, *Hypopitys* and *Monotropa* are more primitive, and the feebly developed sheath of fibers is a primitive character in the stem of *Monotropa.* We may take it that in most respects *Monotropsis* represents a direct ancestor of *Hypopitys,* and *Pityopus* an only slightly modified descendant; *Monotropa* stands apart from all three, differing not only in the well known solitary flower and in the anatomy of the stem, but also in the number of grooves on the pollen grain. We may safely maintain *Hypopitys* and *Monotropa* as separate genera.

The tribe Pleuricosporeae has ceased to be tenable as constituted. The common characters of *Pleuricospora* and *Hemitomes,* in habit, floral diagram, placentation, and ovules, are features all of which are apparently readily reached by parallel change and some of which are widely distributed. They are outweighed by the differences in pubescence, vascular anatomy of the receptacle, and structure of the anther.

Pleuricospora is strictly glabrous. The petal bundles, not forking into two large bundles and one small one, are those of Pterosporeae rather than of Monotropeae. The anther is unique; the only thing elsewhere in the group that suggests it is that of *Pterospora.* The four-grooved pollen grains again suggest Pterosporeae rather than Monotropeae. But we cannot connect this genus with any one genus of Pterosporeae.

Hemitomes has the floral diagram of *Hypopitys,* and, in more extreme form, the irregularity of inflorescence observed in that genus. We may account for the unique petal trace of two bundles by supposing the small middle bundle of the petal traces of the Monotropeae to have been suppressed, this suppression being associated with loss of saccate bases to the petals and pairing of the lobes of the nectary. The slits along the dorsal sides of the dorsal sacs of the anthers seem to amount to a modification of the pores of normal Ericales, which are still present in *Monotropsis* and *Monotropa.* The two-grooved pollen grains are those of most Monotropeae.

It would be possible to dispose of these genera by assigning one to Pterosporeae, the other to Monotropeae, distinguishing these tribes by glabrous stamens and pistils in the former, pubescent stamens and pistils in most of the latter. Such a scheme,

however, would increase the heterogeneity of the Pterosporeae and break the unity of the Monotropeae. I think it best to place each of these genera in a separate tribe, making altogether four tribes to be distinguished as follows (the oriental genus *Cheilotheca* remains unplaced; it may perhaps constitute a fifth tribe):

A. Stamens and pistils glabrous; lobes of the nectary not paired; no gaps above the petal bundles, to which the outer whorl of stamen bundles are more or less fused; grooves on the pollen grain 4 (3 in *Allotropa*); young stems not nodding.
   1. Stems erect above ground; red pigment present; anther bent inward; placentation axile below: Tribe Pterosporeae: *Pterospora, Sarcodes, Allotropa.*
   2. Inflorescence at ground level; red pigment absent; anthers erect; placentation parietal: Tribe Pleuricosporeae: *Pleuricospora.*

B. Stamens and pistil often pubescent; red pigment usually absent (present in varieties of *Monotropa*, a trace of it in *Hemitomes*); gaps present above the petal bundles; grooves on the pollen grain 2 (3 in *Monotropa*).
   1. Bases of petals saccate; lobes of the nectary in pairs; petals with small dorsal bundles and large lateral bundles; young stems nodding (unknown in *Pityopus*): Tribe Monotropeae: *Monotropsis, Hypopitys, Pityopus, Monotropa, Monotropastrum, Wirtgenia?*
   2. Base of petals not saccate; lobes of the nectary evenly distributed; dorsal bundles of the petals suppressed; inflorescence at ground level: Tribe Hemitomeae: *Hemitomes.*

Sacramento Junior College,
Sacramento, California,
August, 1940.

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PODOCARPUS GRACILIOR IN CULTIVATION

John T. Buchholz

The "African fern-pine," in recent years popular as a decorative tub plant and also planted in the open as an ornamental conifer, may become a tree of considerable size. Since mature specimens growing in California have produced pollen cones during the past winter, it is now possible to identify the species as *Podocarpus gracilior* Pilger.

The plant has been regarded as a conifer of South African origin and has usually passed under the nursery trade name of "Podocarpus elongata," which is unquestionably an error. The latter is the legitimate name of a plant of South Africa where there are two narrow leaved species that have been confused and have at one time or another passed under this botanical name. The California exotic has narrow leaves that are somewhat similar to those of *Podocarpus elongatus* L'Herit. (the earliest described

species in this genus), but the pollen cones and seeds differ considerably. It resembles *P. falcatus* (Thunb.) R. Br. (*P. elongata* Carr.) more closely than *P. elongatus* L'Herit., but has green instead of brown twigs, leaves that become longer and wider, and pollen cones that are more than twice as long; also the tips of individual microsporophylls (connectives) of the pollen cones are more pointed. In both *P. gracilior* and *P. falcatus* the pollen cones are axillary, borne singly or in fascicles of two or three.

The seeds of *Podocarpus gracilior* were brought over from East Africa in 1911 by Mrs. Stewart Edward White. Franceschi, of Santa Barbara, germinated some, if not all, of these. The statement is usually current that these seeds were introduced from South Africa (an error which has appeared in print), but the material itself does not agree with the descriptions of either of the narrow-leaved South African podocarps. It fits very closely the description of *Podocarpus gracilior.* This entire question has been clarified recently by a letter received from Colonel Stewart Edward White in which he states that the tree from which these seeds were collected was located in Kenya, British East Africa. This region of Africa is included in the range given for *Podocarpus gracilior* Pilger. Specimens of this species at the United States National Herbarium were collected in Kenya by Edgar A. Mearns of the Smithsonian African Expedition which was led by Theodore Roosevelt in 1909–1910. The male flowering material collected in California in January and February, 1941, in three widely separated localities agrees in all essential details with the Mearns specimens.

Podocarpus gracilior is dioecious, as are nearly all species of *Podocarpus.* Except for the limited number of original seedlings, the trees in California have been propagated from cuttings. The stock tree used for propagation since about 1922 at the Coolidge Rare Plant Garden Nursery in Pasadena is a male tree. During the past winter Mr. J. J. Mulvihill has kindly sent me a number of reproductive twigs. Thousands of plants have been grown as cuttings from this tree over a period of years and furnished to the nursery trade under the names "African Fern-Pine" and "Podocarpus elongata." They do very well as tub plants and when these long-suffering decoratives become too old they may be transplanted to parks and gardens. The writer has seen this conifer used as a street tree in Los Angeles and Pasadena. Apparently they do not become reproductive until they are mature specimens of large size. The largest known specimen, about fifty feet high, is growing at Alameda Plaza in Santa Barbara where two other mature specimens may be seen, none of which had been observed in reproductive condition. However, during July, 1941, Mr. Van Rensselaer of Santa Barbara Botanic Garden found one of these (located in the east section of Alameda Plaza) bearing seeds. Many of the seeds were abortive when less than half grown; some

FIG. 1. Twigs of *Podocarpus gracilior* Pilger bearing nearly full grown pollen cones, January, 1941.

had enlarged to full size, but all of those which were examined by the writer, were without embryos, with the endosperms shriveled in the manner usual for unpollinated parthenocarpic seeds.

With this one exception, all reproductive specimens of *P. gracilior* thus far observed have proved to be male, although presumably the seeds would produce equal numbers of male and female seedlings. The location of many of the original seedlings is not known. Two specimens growing on the estate of Colonel Stewart Edward White near Burlingame have not been observed in reproductive condition at any time. The three large trees at Alameda Plaza are probably seedlings, and likewise any other old specimens growing in Santa Barbara. It is likely that the tree belonging to Mrs. E. N. Hazard, mentioned by Van Rensselaer (Trees of Santa Barbara 1940, p. 84) is also one of the original seedlings. In 1936 the writer found five or six large specimens on the Dwight Murphy estate at Montecito, Santa Barbara County and these may be seedlings. They have not been observed in reproductive condition.

The late Miss Kate Sessions of San Diego informed the writer in 1936 that she had obtained three of the original seedlings from Franceschi. The location of two of them was given. One is growing in the gardens of Julius Wangenhein, 148 West Juniper Street, San Diego. Another is the large tree at the Rosecroft Gardens in San Diego. The latter plant was not reproductive in

1936, but was found with pollen cones during the past winter. Mr. A. D. Robertson furnished the writer with male reproductive specimens from this plant in January and February, 1941.

A male tree growing in the Botanical Garden of the University of California, Berkeley, was observed to be in reproductive condition in January, 1941, by Mr. Donald G. Nelson of that institution. The origin of this plant is not known to the writer. Aside from the dozen plants enumerated here, there are probably a number of other specimens in cultivation on private estates that represent original seedlings, which were distributed in the days before it was discovered that these plants are easily propagated.

University of Illinois, Urbana,
July 21, 1941.

THE TAXONOMIC STATUS OF MICROSTERIS GREENE

Herbert L. Mason

Perhaps no member of the Polemoniaceae has been so greatly misunderstood as the very polymorphic aggregate species, *Phlox gracilis* (Dougl.) Greene. It has been variously treated as a member of the following genera: *Gilia, Collomia, Phlox, Navarretia, Polemonium,* and is the type species of the genus, *Microsteris* Greene; it has been divided and subdivided into species, subspecies, varieties, subvarieties and forms within these genera according to the particular whim of the author treating it. The plant ranges from the Pacific Coast to the Rocky Mountains and from temperate Alaska south to Mexico, and recurs in the Southern Hemisphere in Bolivia, Chile, and Argentina. Essentially an early spring annual, it occurs from the coastal bluffs to timberline. The intent of the present paper is to deal only with the generic position of the aggregate species and not to be concerned with the status and disposition of the smaller taxonomic units. Therefore, the entire group of variants will be treated, for the present at least, as one large, polymorphic species.

The species was first collected by Douglas on the banks of the Spokane River [Washington] and given the manuscript name, *Collomia gracilis;* it was first described by Hooker (6) in 1829 under the name *Gilia gracilis* with *Collomia gracilis* Douglas cited as a synonym. In 1887 Greene (4) referred the species to the genus *Phlox* with the statement: "This interesting plant came to the knowledge of botanists some years in advance of *Phlox Drummondii* Hook. and its allies. It was at first a thing of dubious aspect, not at home either in *Gilia* or *Collomia.* But since the discovery of the Texan group of annual species of *Phlox* with peculiar habit, it must have been the mere force of custom which has kept men from seeing that it is an absolutely perfect congener of *Phlox Drummondii.*" In 1891 (7, p. 433) O. Kuntze, recognizing the page priority of *Navarretia* over *Gilia,* made a purely nomencla-

torial shift in the combination *Navarretia gracilis* (Dougl.) Kuntze. In 1898 Greene (5) erected the genus *Microsteris* recognizing as species seven segregates of *Phlox gracilis*. In so doing Greene stated: "At present I am disposed to adopt it as a principle that species with mucilaginous seeds are nowhere, in this family, to be placed as congeneric with such as have seeds devoid of the gummiferous coating. This implies the removal of my *Phlox gracilis* from the genus *Phlox*." In his description of *Microsteris* he states "Calyx, corolla, stamens and capsule wholly as in *Phlox*." Thus Greene's *Microsteris* hangs by the single character "mucilaginous seeds." In the same year O. Kuntze (8, p. 203) referred *Collomia gracilis* Dougl. to *Polemonium* by the simple statement: "P. Morenonsis OK (Collomia gracilis Dgl. non Polemonium gracile)." His reasons are forever hidden in parenthetical synonymy. We can dismiss without further comment the references to *Navarretia* and *Polemonium*. The reference by Douglas to *Collomia* is understandable. It was based upon superficial resemblance; furthermore, at that time the genus *Collomia* had not been clearly circumscribed in the light of the family as a whole. Our problem resolves itself into determining whether *Phlox gracilis* shall be retained in *Gilia* as interpreted by Hooker, be retained in *Phlox* as interpreted by Greene in 1887 or be placed in *Microsteris* following Greene's later interpretation. Of subsequent authors most have preferred to follow Asa Gray's adaptation of Hooker's treatment in a broad concept of the genus *Gilia* while only a few have used either *Phlox* or *Microsteris* when referring to this species. Brand (2) in his monograph of the Polemoniaceae with its highly elaborated system of "pigeon holes" chose to place *Phlox gracilis* in the genus *Gilia*, subgenus Benthamiophila, section Phlogastrum and proceeded to divide the species into fourteen entities in various subspecific categories. With respect to the generic position of the species I quote from Brand, "Species sic intermedia inter genera *Phlox* et *Gilia*, ut vix discernere possis, cui generi eam attribuas; a *Collomia* tamen, quacum plurimi autores junxerunt, calyce, ut cl. Greene docuit, valde diversa." Although he cited *Microsteris* as a synonym it is clear from the above quotation that he did not regard *Microsteris* as offering any problem. He was concerned with differentiating *Gilia* from *Phlox*. Here again we find but a single character utilized to place the species in *Gilia*, namely, the fact that the seeds develop mucilage when wetted. Other characters which it possesses that align it with *Phlox* are treated by Brand as exceptions in *Gilia*.

The most recent treatment that bears on this problem is that of Wherry (9) from whom we quote, "*Microsteris*. A few diminutive western annuals constitute this genus, which has been by various authors referred to *Collomia, Gilia* and *Phlox*. It shows little relationship with the first two genera, and in view of the difference in seeds can scarcely be congeneric with the last, although it may well be a derivative." Wherry, it will be seen, dismisses

Gilia and *Collomia* from consideration but parries between *Phlox* and *Microsteris*. He finally eliminates *Phlox* on the basis of "COROLLA-LIMB small; seeds becoming sticky when moistened," but he does at least suggest the responsibility of *Phlox* for the offspring. In an effort to validate the genus *Microsteris* another very insignificant character is added to the one previously utilized, namely the small size of the corolla limb.

It is perhaps a reasonable mode of escape when a group of plants does not fit comfortably in any of the related genera to erect a genus for it. However, this procedure should not be adopted until all of the evidence is carefully weighed to determine the precise nature of the differences that seem to make it necessary. As pointed out above *Microsteris* was erected by Greene who listed for it a single character difference from *Phlox*. Wherry's additional character of a small corolla limb adds scarcely anything of generic significance. The following tabular arrangement presents the facts pertaining to the development or non-development of mucilage or spiracles in the seed coats of most of the more widely accepted genera or Polemoniaceae.

Bonplandia: all species develop mucilage.

Cantua: a few species develop spiracles, the rest do not.

Cobaea: some species produce spiracles, and other species mucilage.

Gilia: very diverse, some species produce mucilage, others do not. The section *Ipomopsis,* recognized as a distinct genus by Wherry, is about equally divided in this respect.

Hugelia: some species produce mucilage, others do not.

Langloisia: all species produce mucilage.

Leptodactylon: in species examined none produce mucilage.

Linanthus: most species produce mucilage, some do not.

Loeselia: some produce mucilage, others do not.

Navarretia: some produce mucilage, others do not.

Phlox: as interpreted by Greene and by Wherry, does not produce mucilage, but if *Microsteris* is included, will be on the same basis as the other large genera.

Polemonium: some species produce mucilage, others do not.

The remaining few genera are each very small, and I have not as yet investigated them. But from the above data it would appear that the development of mucilage by the seed coat cannot be relied upon as of primary generic significance. All we can say of *Phlox* is that in the majority of species the seeds are immutable when wetted. This leaves as a character for the segregation of *Microsteris* only the small corolla limb. The magnitude of difference here, however, is no greater than the variational limits of corolla size in several other genera of Polemoniaceae, such as *Collomia, Navarretia* and *Linanthus.* This evidence, it seems, is just cause for denying generic status to *Microsteris.*

When we consider the characters that serve to keep the *Phlox gracilis* aggregate out of *Gilia* we turn from the flower and seed to

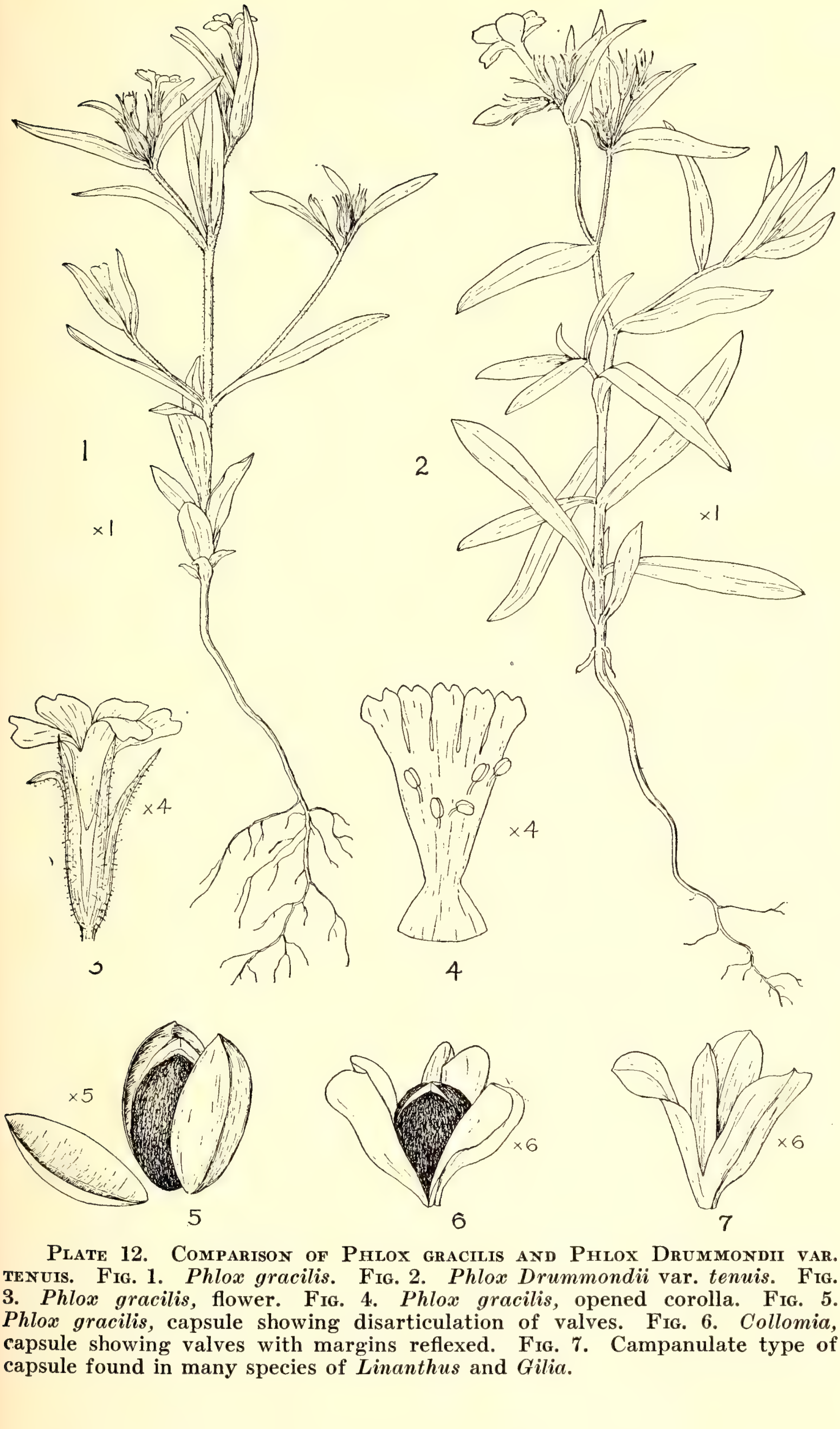

Plate 12. Comparison of Phlox gracilis and Phlox Drummondii var. tenuis. Fig. 1. *Phlox gracilis*. Fig. 2. *Phlox Drummondii* var. *tenuis*. Fig. 3. *Phlox gracilis,* flower. Fig. 4. *Phlox gracilis,* opened corolla. Fig. 5. *Phlox gracilis,* capsule showing disarticulation of valves. Fig. 6. *Collomia,* capsule showing valves with margins reflexed. Fig. 7. Campanulate type of capsule found in many species of *Linanthus* and *Gilia*.

other parts of the plant. Of the authors who have referred the group to *Gilia* we find some who regard most of the small genera (*Linanthus, Hugelia, Gymnosteris, Loeselia, Collomia, Leptodactylon*) as belonging to this genus; others who recognize the small genera mentioned above but who have followed precedent in the disposition of *Phlox gracilis*. When we exclude from *Gilia* these small genera there still remains a polymorphic but closely related group of species. The leaves of this remaining group are normally alternate (occasionally through shortening of the internodes they may appear subopposite), and frequently pinnately toothed, lobed or dissected; the corolla lobes are normally entire; the stamens are usually, but not always, equally inserted and equal in length; the capsule valves do not disarticulate on dehiscence but remain united at the base, and although the valves may spread campanulately or sometimes reflex on the midvein the capsule falls as a whole (pl. 12, fig. 7); the locules of the ovary are usually more than one-seeded, but occasionally are one-seeded; the seeds are usually small and angular.

Phlox gracilis does not conform with *Gilia* as the following summary of its characters demonstrates: the leaves are predominately opposite (pl. 12, fig. 1), at least below, and are always linear, or oblong and entire; the corolla is salverform, the limb rotate, the lobes frequently emarginate (pl. 12, fig. 3); the stamens are unequally inserted and unequal in length (pl. 12, fig. 4); the capsule valves are rigid and disarticulate completely on dehiscence; the locules are one-seeded, the seeds large (pl. 12, fig. 5). Greene was quite correct when he said in his diagnosis of *Microsteris*, "Calyx, corolla, stamens and capsule wholly as in *Phlox*." And of course Wherry accepts for this group a close relationship to *Phlox*. It seems that the presence of such typical *Phlox* characters as the rigid, disarticulating capsule valves and the solitary large seeds in the locules, together with several minor characters which are usual in *Phlox* and occasional or abnormal in *Gilia*, throw the weight of the argument to *Phlox*, not to *Gilia*.

Another line of evidence supporting a relationship with *Phlox* rather than with *Gilia* is found in cytological studies; the basic chromosome number in *Gilia* appears to be $n = 9$ while the basic chromosome number in *Phlox* is $n = 7$. In *Phlox gracilis* $2n = 14$, the count being made from root tip cells. However, in a group with such wide climatic tolerance and such great morphological diversity we may anticipate some polyploidy.

Botanists familiar with the genus *Phlox* only in western North America may be pardoned for hesitating to place *P. gracilis*, a plant so different from *P. Douglasii* and *P. adsurgens*, in the same genus. It is, as Greene points out, only when we take into consideration the range of variation of the entire genus that we can hope for a true picture of relationship. In this case the *Phlox Drummondii* complex of Texas offers a key to the relationship. A collection of *Phlox Drummondii* var. *tenuis* Gray from Texas

(*Lindheimer 468*) is an excellent example of a connecting type between *Phlox gracilis* and other members of the genus. A comparison of figures 1 and 2 (pl. 12) will at once show the great similarity in aspect between the two. Figure 1 represents a plant of *Phlox gracilis* collected at Tuolumne Meadows, Yosemite National Park, California (*Mason 4869*). It was especially selected for this comparison but is representative of a large segment of the "*Microsteris*" variants. The evidence of a general similarity of aspect substantiated by indisputable *Phlox* characters upholds Greene's first opinion of the generic position of this group.

The fact that this western group of plants is related to an eastern group by way of a southern bond is not inconsistent with the growing body of information now being accumulated relative to the history of vegetation in the southwest. Among other genera with related species showing a similar distribution pattern are *Juglans, Cercis, Forestiera* and *Fraxinus.* This group of trees and shrubs are all represented in fossil floras of Middle Tertiary time and today occur in savanna like floras where *Phlox gracilis* is a common associate. It would seem that these relationships go back at least as far as the Miocene, if not the Oligocene, in the Sierra Madrean flora of Axelrod (1). Perhaps this region has been the center of origin and differentiation of the entire Polemoniaceae. Certainly not all *Phlox* species have had their origin in Keewatin Land as postulated by Wherry (10). If this were true it would be reasonable to expect a higher development of the genus in the old world than is now evident, since migration routes through Beringia would have been available. The occurrence of *Phlox* in this northern region during the Pleistocene, north and west of the Keewatin center of glaciation is attested by fossil fruits reported and figured by Chaney and Mason (3 p. 17, figs. 34, 36). These specimens are strikingly similar to *P. sibirica* L., a species occurring in the Alaska region today, and ranging westward into Siberia.

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August 27, 1941.

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THE HOLACANTHOID PLANTS OF NORTH AMERICA

Cornelius H. Muller

One of the striking botanical phenomena of the southwestern United States and adjacent Mexico is the occurrence of several genera of different families with vegetative characters so similar as to make them confusing. Perhaps the most outstanding such instance is that of the usually leafless green spiny shrubs which resemble *Holacantha Emoryi* A. Gray, a member of the Simarubaceae. The similar forms are *Koeberlinia spinosa* Zucc. in the Koeberliniaceae, *Canotia holacantha* Torr. in the Celastraceae, and *Thamnosma montana* Torr. & Frem. in the Rutaceae.

These four species are characterized by leaves reduced to scales and early caducous, and spinescent stems persistently green to carry on the photosynthetic process. The lack of leaves and similarity of the spines make these plants rather difficult to distinguish without flowers or fruit. Yet, a series of vegetative characters may be recognized by which the species are readily distinguished.

There are other spinescent plants which might be confused with the group here treated. The others, however, are characterized by shorter and more slender spines and usually more prominent leaves. For instance, *Adolphia* in the Rhamnaceae and *Forsellesia* in the Celastraceae contain species highly similar in habit to the Holacantha-like plants, but in these the spines do not exceed an average of 2.5 millimeters in thickness, and the leaves are prominent throughout the greater part of the growing season. Furthermore, *Adolphia* is characterized by opposite leaves and branches, while those of the plants here treated are all alternate. Two variants of *Koeberlinia spinosa* have been distinguished under varietal names. Both of these are characterized by very slender spines which might make them difficult to distinguish from *Adolphia* except for their alternate habit of branching. Leafless individuals of the leguminous shrubs *Cercidium* and *Cassia armata* might become confusing when they lack flowers and fruit.

The highly artificial group comprised of the Holacantha-like plants is characterized by the alternate-branching, spinescent stems, the spines usually quite coarse, branches green and photosynthetically functional for several years, leaves much reduced and early caducous. Johnston (Journ. Arn. Arb. 21: 356–363. 1940) has pointed out the significance of this group of unrelated plants of similar habit as indicative of a relationship between the North American deserts and those of South America where the same habit is common. He showed the habit to be much more general in the South American deserts than in North America. The highly endemic character of all our species except *Koeberlinia spinosa* would indicate that the plants are relicts of a time when the habit was more common in North American deserts.

Key Based on Vegetative Characters

Leaf scars and branching alternate, leaves inconspicuous and early caducous.
- Plants glabrous, stem either densely glandular or with minute longitudinal lines of white waxy flakes.
  - Stems densely glandular or warty with translucent glands; buds and spine tips tan; branches with a pair of extra-axillary buds at the bases (one on each side) .... *Thamnosma*
  - Stems not glandular, with minute longitudinal lines of white waxy flakes; buds dark brown or black, spine tips brown; branches with no extra-axillary buds *at* the bases (though the buds along the length of the branch may descend to a point *near* the base) .... *Canotia*
- Plants with young stems pubescent, neither glandular nor with waxy exudations.
  - Younger stems yellow-green, minutely puberulent with short spreading hairs or these reduced to pustules; branches and spines with a pair of buds at the bases, these extra-axillary (one on each side) .... *Koeberlinia*
  - Younger stems gray green with densely matted appressed silky hairs; branches and spines with a single axillary bud and no lateral or extra-axillary buds at the bases .. *Holacantha*

Leaf scars and branching opposite or, if alternate, the leaves conspicuous and persistent . . . (genera not treated in this article).

Thamnosma montanum Torr. & Frem. in Frem., Rep. Exped. Rocky Mts. 313. 1845.

Central Arizona north to southwestern Utah, southern Nevada, and southern California; most common in western Arizona. A shrub usually 3 to 6 or 7 decimeters tall. (fig. 1).

Canotia holacantha Torr., U. S. Rep. Survey Railroad Miss. Pac. 4: 68. 1856.

Southeastern and central Arizona to northwestern Arizona and doubtfully in the Providence Mountains of southeastern California. A shrub 3 to 5 or even 6 meters tall. (fig. 2.)

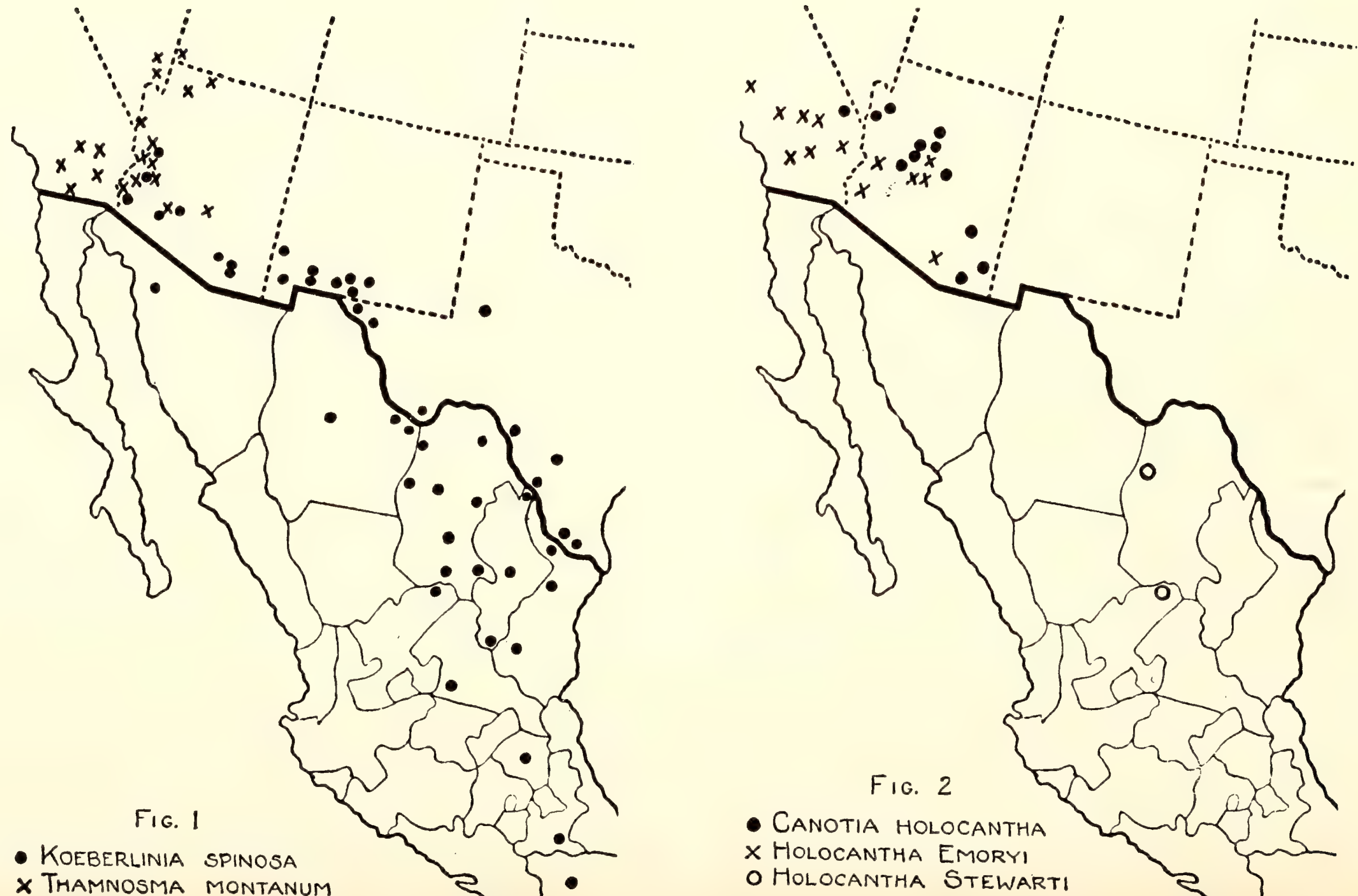
Koeberlinia spinosa Zucc., Abh. Akad. Muench. 1: 359. 1832.

Southern Arizona and New Mexico, western Texas, Baja California, northern Sonora and Chihuahua, south through Coahuila and Nuevo Leon to Puebla and Oaxaca. A shrub 0.5 to 2 meters or even a small tree to 5 meters tall. (fig. 1.)

Koeberlinia spinosa var. tenuispina Kearney & Peebles, Journ. Wash. Acad. Sci. 29: 486. 1939.

Yuma County, Arizona, and Sonora, Mexico. Differs from the species in its elongate slender spines, blue-green color, and usually longer sepals, petals, and filaments. Typical *K. spinosa* apparently occurs nowhere west of Tucson, Arizona. This variety is not distinguished from the species on the distribution map.

A second variety (*K. spinosa* var. *verniflora* Bogusch, Torreya 31: 74. 1931) now scarcely seems worthy of distinction. Although this form differs strikingly from the species by its slender spines (and generally reduced size of the organs) and its early flowering (in March and April), its differences are not sufficiently profound nor constant to warrant formal recognition. Nor is



Figs. 1 and 2. Distribution of holocanthoid plants in southwestern North America.

there any geographical segregation from the species. The morphological basis of this form has been observed by the author in various parts of western Texas and adjacent Chihuahua and Coahuila. In a letter to the author under the date October 7, 1940, Bogusch discusses the variety as follows: " . . . observations made in the field upon specimens of *Koeberlinia spinosa* Zucc. convince me that the variety *verniflora* described by me is probably a normal reaction of the plant to wound stimulus or represents a form of juvenile growth. From material seen both in the type locality of the Rio Grande Valley of Texas and in the region west of Uvalde, I have seen that new growth which follows extensive injury to the plant often results in being more attenuated, both in branches and the spines. The peculiarities associated with the time of flowering—not necessarily a taxonomic character—may be best explained that in the Rio Grande Valley the vegetation in many respects matures earlier and comes into flower sooner than elsewhere in the state."

Holacantha Emoryi A. Gray, Mem. Am. Acad. ser. 2, 5 (Pl. Nov. Thurb.): 310. t. 8. 1855.

Central and southwestern Arizona to southern California. A shrub 1 meter tall to a small tree reaching 3.5 meters (fig. 2).

An undescribed species of *Holacantha* was recently discovered in northen Mexico.

Holacantha Stewartii sp. nov. Frutex procumbens vel adscendens 1.5–3(6) dm. altus duplo latior; spinae plusminusve appresso- vel patenti-pubescentes glabratae, papillis minutis exceptis; fructus acutus margine ventrali obtuso-costatus.

Low shrub, 1.5–3 dm., rarely 6 dm. tall, usually 2–4 times as broad, procumbent or somewhat ascending, soon leafless, coarsely spiny; stems and spines divaricate; spines 2.5–6(12) cm. long, (1.5)2.5–3 mm. thick, tips subulate, brown, 3–4 mm. long, branches terete, the immature ones becoming sulcate in drying, glabrate or somewhat spreading-pubescent or appressed-sericeous, hairs short, bases persisting as minute papillae; buds inconspicuous in axils of spines and sparsely scattered along their length, surrounded by small tufts of coarse appressed hairs; leaves quickly deciduous, oblong, acute at both ends, sessile, 5–8 mm. long, 2–2.5 mm. broad, red at vernation (as are the young spines for a time), densely white- or rose-hirsute, becoming green and sparsely hirsute; flowers dioecious; staminate calyx of 6 ovate, acute, pubescent sepals about 1 mm. long; corolla of 6 fleshy, dorsally pubescent, deeply concave petals with narrow, thin margins, 4 mm. long, 1.75 mm. broad (not flattened), stamens about 12, filaments 1.5–2 mm. long, broadened basally, strongly hirsute, apex subulate, glabrous; pistillate calyx similar to the staminate; pistillate corolla not seen; staminodes similar to the functional filaments; carpels distinct, apically connivent, stigmas sessile, fused; fruit persistent 1–2 years, 6-carpellate (or carpels fewer

by abortion), carpels distinct, divaricate, lenticular-ovate, acute, ventral margins obtusely ridged, superior, 8–9 mm. long, 5–6 mm. broad, 3–4 mm. thick, glabrous, red or green, surface nearly smooth, lacquered. (fig. 2.)

Range: Mexico; western Coahuila and northern Zacatecas.

Holacantha Stewartii is named in honor of Mr. Robert M. Stewart of Santa Elena, Coahuila, whose superior hospitality and whose company on several side trips contributed markedly to the pleasure and success of the several weeks' work in the vicinity.

This species is the second described in this rare and striking genus, the first being *Holacantha Emoryi* which is confined to Arizona and California. From that species *H. Stewartii* differs in its low sprawling habit, the sparse pubescence of its stems (compared with the densely short-tomentose stems of *H. Emoryi*), the persistence of papillae-like hair-bases, and its usually markedly acute and ventrally ridged carpels. The great discrepancy in the ranges of these two endemics further attests their distinctness.

Specimens examined. Coahuila: Sierra de las Cruces, gulch in limestone hills 0.5 mile north of Santa Elena, August 13, 1940, *I. M. Johnston & C. H. Muller 215* (United States National Arboretum, USNA, type, sheet no. 96733; Arnold Arboretum, AA); southeast base of Sierra de las Cruces, 3 miles northeast of San José, September 5, 1940, *I. M. Johnston & C. H. Muller 1003* (AA, USNA); north base of Sierra de las Cruces, at San Rafael, September 8, 1940, *I. M. Johnston & C. H. Muller 1034* (AA, USNA); northwest base of Sierra de las Cruces, at San Vicente, September 8, 1940, *I. M. Johnston & C. H. Muller 1065* (AA, USNA); 3 to 5 miles south of Laguna de Jaco, September 10, 1940, *I. M. Johnston & C. H. Muller 1104* (AA, USNA); north end of Bolson de los Lipanes between El Almagre and Cerros de Leja, September 12, 1940, *I. M. Johnston & C. H. Muller 1239* (AA, USNA). Zacatecas: banks of arroyos in foothills, Hacienda de Cedros, 1908, *F. E. Lloyd 191* (United States National Herbarium).

With the exception of the type collection and Lloyd's from Zacatecas all the plants collected or observed grew in deep, heavy silt flats, usually associated with *Koeberlinia spinosa* Zucc. Although the most luxuriant growth and fruiting occurs in rocky arroyo sites, the species is obviously more at home in the former habitat, as is evidenced by its more frequent occurrence there. The plant is often the only one (or one of a few) on otherwise bare silt. Its procumbent habit serves to bind the soil and forms hillocks down the sides of which the branches sprawl.

In two of the seven collections studied fasciated stems were noted. These are flattened and falcate with two ranks of simple normal spines issuing from their edges. It is odd that two such cases of identical abnormality were encountered in so rare a plant, about fifty individuals being observed in the course of a wide and painstaking search.

Bureau of Plant Industry, Washington, D. C., February, 1941.

COMBINATIONS PROPOSED IN "THE HIGHER PLANTS OF OREGON"

Morton E. Peck

There has been some question as to the validity of certain new combinations proposed in the "Manual of the Higher Plants of Oregon," recently published by the writer. The citations required if one is to adhere strictly to the International Rules (Ch. 3, Sec. 6, Art. 44), are, therefore, published herewith. Numbers in parentheses refer to pages of the "Manual" on which the new combination was made.

Tofieldia occidentalis Wats. var. **intermedia** (Rydb.) comb. nov. *T. intermedia* Rydb., Bull. Torr. Club 27: 528. 1900. (p. 189)

Brodiaea Douglasii var. **Howellii** (Wats.) comb. nov. *B. Howellii* Wats., Proc. Am. Acad. Sci. 14: 301. 1879. (By error as *B. grandiflora* var. *Howellii,* p. 199)

Habenaria elegans var. **multiflora** (Rydb.) comb. nov. *Piperia multiflora* Rydb., Bull. Torr. Club 28: 638. 1901. (p. 219)

Eriogonum ovalifolium var. **ochroleucum** (Small) comb. nov. *E. ochroleucum* Small, Mem. N. Y. Bot. Gard. 1: 123. 1900. (p. 256)

Atriplex patula var. **obtusa** (Cham.) comb. nov. *A. angustifolia* var. *obtusa* Cham., Linnaea 6: 569. 1831. (p. 267)

Lewisia Cotyledon var. **Howellii** (Wats.) comb. nov. *Calandrinia Howellii* Wats., Proc. Am. Acad. Sci. 23: 262. 1888. (p. 281)

Arenaria aculeata var. **uintahensis** (Nels.) comb. nov. *A. uintahensis* Nels., Bull. Torr. Club 28: 7. 1899. (p. 286)

Silene oregana Wats. var. **filisecta** comb. nov. *S. filisecta* Peck, Proc. Biol. Soc. Wash. 47: 186. 1934. (p. 296)

Anemone globosa var. **lithophila** (Rydb.) comb. nov. *A. lithophila* Rydb., Bull. Torr. Club 29: 152. 1902. (p. 309)

Aquilegia formosa var. **flavescens** (Wats.) comb. nov. *A. flavescens* Wats., Bot. King Geol. Expl. 40th. Par. 5: 10. 1871. (p. 312)

Dicentra Cucullaria var. **occidentalis** (Rydb.) comb. nov. *Bicuculla occidentalis* Rydb., Bull. Torr. Club 29: 160. 1902. (p. 323)

Draba reptans var. **stellifera** (Schulz.) comb. nov. *D. caroliniana* f. *stellifera* Schulz., in Engler, Pflanzenr. 4^{105}: 333. 1927. (p. 326)

Descurainia Richardsoni var. **viscosa** (Rydb.) comb. nov. *Sophia viscosa* Rydb., Bull. Torr. Club 29: 238. 1902. (p. 340)

Descurainia pinnata var. **filipes** (Gray) comb. nov. *Sisymbrium incisum* var. *filipes* Gray, Pl. Fendl. 8. 1849. (p. 340)

Descurainia pinnata var. **halictorum** (Cockerell) comb. nov. *Sophia halictorum* Cockerell, Bull. Torr. Club 25: 460. 1898. (p. 340)

Descurainia pinnata var. **paradisa** (Nels. & Kenn.) comb. nov. *Sophia paradisa* Nels. & Kenn., Proc. Biol. Soc. Wash. 19: 155. 1906. (p. 340)

Descurainia pinnata var. **Nelsonii** (Rydb.) comb. nov. *Sophia Nelsonii* Rydb., Bull. Torr. Club 34: 436. 1907. (p. 341)

Parrya cheiranthoides var. **lanuginosa** (Wats.) comb. nov. *P. Menziesii* var. *lanuginosa* Wats. in Gray Syn. Fl. 1: 152. 1895. (p. 352)

Streptanthus hastatus (Wats.) comb. nov. *Caulanthus hastatus* Wats., Bot. King Geol. Expl. 40th. Par. 5: 28. pl. 3. 1871. (p. 353)

Sedum glanduliferum (Hend.) comb. nov. *Cotyledon glanduliferum* Hend., Rhodora 32: 26. 1930. (p. 361)

Sedum oregonense (Wats.) comb. nov. *Cotyledon oregonensis* Wats., Proc. Am. Acad. Sci. 18: 373. 1862. (p. 361)

Potentilla gracilis Dougl. var. **dichroa** (Rydb.) comb. nov. *P. dichroa* Rydb., N. Am. Fl. 22: 319. 1908. (p. 393)

Horkelia fusca var. **capitata** (Lindl.) comb. nov. *H. capitata* Lindl., Bot. Reg. 23, sub. pl. 1997. 1837. (p. 398)

Horkelia fusca var. **pseudocapitata** (Rydb.) comb. nov. *H. pseudocapitata* Rydb. in Howell, Fl. N. W. Am. 180. 1898. (p. 398)

Horkelia fusca var. **parviflora** (Nutt.) comb. nov. *H. parviflora* Nutt. ex. Hook. & Arn. Bot. Beechey Voy. suppl. 338. 1838. (p. 399)

Horkelia fusca var. **filicoides** (Crum) comb. nov. *Potentilla Douglasii* var. *filicoides* Crum. Leafl. West. Bot. 1: 100. 1934. (p. 399)

Horkelia congesta var. **nemorosa** (Keck) comb. nov. *H. congesta* subsp. *nemorosa* Keck, Lloydia 1: 108. 1938. (p. 399)

Geum gracilipes (Piper) comb. nov. *Potentilla gracilipes* Piper, Bull. Torr. Club 27: 392. 1900. (By error as *Geum filipes,* p. 402)

Rosa pisocarpa var. **ultramontana** (Wats.) comb. nov. *R. californica* var. *ultramontana* Wats. in Brew. & Wats. Bot. Calif. 1: 87. 1876. (By error as *R. pisocarpa* var. *transmontana,* p. 404)

Cercocarpus ledifolius var. **hypoleucus** (Rydb.) comb. nov. *C. hypoleucus* Rydb., N. Am. Fl. 22: 424. 1913. (p. 407)

Astragalus Laurentii (Rydb.) comb. nov. *Homalobus Laurentii* Rydb., Bull. Torr. Club 51: 15. 1924. (p. 443)

Astragalus subglaber (Rydb.) comb. nov. *Homalobus subglaber* Rydb., Bull. Torr. Club 51: 17. 1924. (p. 444)

Astragalus reventus var. **Hoodianus** (Howell) comb. nov. *A. Hoodianus* Howell, Erythea, 1: 111. 1893. (p. 444)

Astragalus lagopinus (Rydb.) comb. nov. *Xylophacos lagopinus* Rydb., Bull. Torr. Club 52: 372. 1925. (p. 445)

Astragalus Hookerianus var. **siskiyouensis** (Rydb.) comb. nov. *Phaca siskiyouensis* Rydb., N. Am. Fl. 24: 340. 1929. (p. 446)

Astragalus Forwoodii var. **wallowensis** (Rydb.) comb. nov. *Atelophragma wallowense* Rydb., Bull. Torr. Club 55: 122. 1928. (p. 447)

Astragalus conjunctus var. **Sheldoni** (Rydb.) comb. nov. *Tium Sheldoni* Rydb., N. Am. Fl. 24: 393. 1929. (p. 448)

Astragalus lentiginosus var. **cornutus** (Rydb.) comb. nov. *Cystium cornutum* Rydb., N. Am. Fl. 24: 412. 1929. (p. 449)

Astragalus lentiginosus var. **platyphyllidium** (Rydb.) comb. nov. *Cystium platyphyllidium* Rydb., N. Am. Fl. 24: 410. 1929. (p. 449)

Viola praemorsa var. **major** (Hook.) comb. nov. *V. Nuttallii* var. *major* Hook., Fl. Bor. Am. 1: 79. 1830. (p. 486)

Viola praemorsa var. **linguaefolia** (Nutt.) comb. nov. *V. linguaefolia* Nutt., Torr. & Gray, Fl. 1: 141. 1838. (p. 486)

Viola purpurea var. **atriplicifolia** (Greene) comb. nov. *V. atriplicifolia* Greene, Pitt. 3: 38. 1896. (p. 486)

Epilobium glandulosum var. **cinerascens** (Piper) comb. nov. *E. cinerascens* Piper, Proc. Biol. Soc. Wash. 31: 75. 1918. (p. 494)

Epilobium paniculatum var. **Hammondi** (Howell) comb. nov. *E. Hammondi* Howell, Fl. N. W. Am. 224. 1903. (p. 497)

Menziesia ferruginea var. **glabella** (Gray) comb. nov. *M. glabella* Gray, Syn. Fl. N. Am. 2: 39. 1878. (p. 542)

Phlox speciosa var. **occidentalis** (Dur.) comb. nov. *P. divaricata* var. *occidentalis* Dur., Proc. Acad. Nat. Sci. Phila. 3: 97. 1855. (p. 570)

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Phlox longifolia var. **compacta** (Brand) comb. nov. *P. Stansburyi* var. *compacta* Brand in Engler, Pflanzenr. 4^{250}: 67. 1907. (p. 571)

Phlox longifolia var. **longipes** (Jones) comb. nov. *P. linearifolia* var. *longipes* Jones, Contrib. West. Bot. 12: 53. 1908. (p. 571)

Phlox longifolia var. **humilis** (Dougl.) comb. nov. *P. humilis* Dougl. ex Hook. Fl. Bor. Am. 2: 72. 1838. (p. 571)

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Phlox Douglasii var. **rigida** (Benth.) comb. nov. *P. rigida* Benth. in DC., Prodr. 9: 306. 1845. (p. 571)

Phlox Douglasii var. **Hendersonii** (E. Nels.) comb. nov. *P. condensata* var. *Hendersonii* E. Nels., Rev. W. N. Am. Phlox 14. 1899. (p. 571)

Phlox diffusa var. **longistylis** (Wherry) comb. nov. *P. diffusa* subsp. *longistylis* Wherry, Proc. Acad. Nat. Sci. Phila. 90: 139. 1938. (p. 572)

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fusa subsp. *subcarinata* Wherry, Journ. Wash. Acad. Sci. 29: 517. 1939. (p. 572)

Phlox diffusa var. **scleranthifolia** (Rydb.) comb. nov. *P. scleranthifolia* Rydb., Mem., N. Y. Bot. Gard. 1: 313. 1900. (p. 572)

Phlox Hoodii var. **canescens** (Torr. & Gray) comb. nov. *P. canescens* Torr. & Gray, Pac. R. Rept. 2^2: 122. 1855. (p. 572)

Aplopappus carthamoides var. **rigidus** (Rydb.) comb. nov. *Pyrrocoma rigida* Rydb., Bull. Torr. Club 27: 624. 1900. (p. 712)

Aplopappus racemosus var. **halophilus** (Greene) comb. nov. *Pyrrocoma halophila* Greene, Leafl. Bot. Obs. & Crit. 2: 16. 1909. (By error as *A. racemosus* var. *halophiloides*, p. 712)

Aplopappus racemosus var. **duriusculus** (Greene) comb. nov. *Pyrrocoma duriuscula* Greene, Leafl. Bot. Obs. & Crit. 2: 16. 1909. (p. 712)

Aplopappus racemosus var. **glomeratus** (Nutt.) comb. nov. *Homapappus glomeratus* Nutt., Trans. Am. Phila. Soc. n. ser. 7: 331. 1840. (p. 712)

Aplopappus racemosus var. **brachycephalus** (Nels.) comb. nov. *Pyrrocoma brachycephala* Nels., Bot. Gaz. 37: 265. 1904. (p. 713)

Aplopappus racemosus var. **congestus** (Greene) comb. nov. *Pyrrocoma congesta* Greene, Pitt. 3: 23. 1896. (p. 713)

Aplopappus lanceolatus var. **tenuicaulis** (D. C. Eat.) comb. nov. *A. tenuicaulis* D. C. Eat., Bot. King Geol. Expl. 40th. Par. 5: 160. 1871. (p. 713)

Aplopappus hirtus var. **sonchifolius** (Greene) comb. nov. *Pyrrocoma sonchifolia* Greene, Leafl. Bot. Obs. & Crit. 2: 18. 1909. (p. 713)

Aplopappus hirtus var. **lanulosus** (Greene) comb. nov. *Pyrrocoma lanulosa* Greene, Leafl. Bot. Obs. & Crit. 2: 16. 1909. (p. 713)

Aplopappus uniflorus var. **Howellii** (Gray) comb. nov. *A. Howellii* Gray, Syn. Fl. 1^2, suppl.: 446. 1886. (p. 713)

Antennaria luzuloides var. **oblanceolata** (Rydb.) comb. nov. *A. oblanceolata* Rydb., Mem. N. Y. Bot. Gard. 1: 409. 1900. (p. 741)

Artemisia campestris var. **spithamaea** (Pursh) comb. nov. *A. spithamaea* Pursh, Fl. Am. Sept. 522. 1814. (p. 768)

Artemisia campestris var. **pycnocephala** (Less.) comb. nov. *Oligosporus pycnocephalus* Less., Linnaea 6: 524. 1831. (p. 768)

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Senecio triangularis var. **trigonophyllus** (Greene) comb. nov. *S. trigonophyllus* Greene, Pitt. 3: 106. 1896. (p. 780)

Crepis runcinata var. **imbricata** (Babc. & Steb.) comb. nov. *C. runcinata* subsp. *imbricata* Babc. & Steb., Carneg. Inst. Wash. Publ. 504: 102. 1938. (p. 804)

CREPIS MODOCENSIS var. **subacaulis** (Kellogg) comb. nov. *C. occidentalis* var. *subacaulis* Kellogg, Proc. Calif. Acad. Sci. 5: 50. 1873. (p. 805)

CREPIS ATRIBARBA var. **originalis** (Babc. & Steb.) comb. nov. *C. atribarba* subsp. *originalis* Babc. & Steb., Carneg. Inst. Wash. Publ. 504: 162. 1938. (p. 806)

CREPIS OCCIDENTALIS var. **pumila** (Rydb.) comb. nov. *C. pumila* Rydb., Mem. N. Y. Bot. Gard. 1: 462. 1900. (p. 806)

CREPIS BAKERI var. **Cusickii** (Eastw.) comb. nov. *C. Cusickii* Eastw., Bull. Torr. Club 30: 502. 1903. (p. 806)

Willamette University,
Salem, Oregon,
August 9, 1941.

AN UNDESCRIBED SPECIES OF STIPA FROM CALIFORNIA

G. L. STEBBINS, JR., AND R. M. LOVE

Due to the growing interest in the native forage plants of California, particular attention is now being given by a number of workers to *Stipa pulchra* Hitchc., one of the most common and valuable of the native perennial forage grasses in the valley and foothill regions of this state. Several people, including the present writers, have noticed that this species as recognized in the current manuals actually consists of two distinct types. One, with deep green foliage, relatively broad leaves, stiffer panicle branches, large glumes, thick, fusiform lemmas, and stout, stiff awns, is predominant in the outer Coast Ranges and the wooded parts of the Sierra Nevada foothills. This is typical *S. pulchra*, of which the type came from Healdsburg, Sonoma County. The other form, with somewhat glaucous foliage, narrower leaves, flexuous, often nodding panicle branches, smaller, narrower glumes, slender lemmas, and slender, often flexuous awns, occurs chiefly in the treeless parts of the inner Coast Ranges, the San Joaquin Valley (in scattered areas undisturbed by cultivation), the valleys of southern California, and the edges of the deserts. The two types have been given different common names, typical *S. pulchra* being known as purple needle grass, and the slender, interior type as nodding needle grass. The writers have observed these two needle grasses carefully during two seasons of collecting in the field, have grown and compiled extensive morphological data on several cultures of each, and have examined their chromosomes at both mitosis and meiosis. From these observations enough evidence has accumulated to warrant the recognition of the interior type as a distinct species. It may be described as follows.

Stipa cernua sp. nov. Folia glauca angusta; panicula ampla, ramis tenuis, flexuosis, cernuis; glumae inaequales, 12–19 mm. longae, 1–1.4 mm. latae, pallidae vel roseo-purpureae, semper 3-nervatae; lemma angusta, 5–10.5 mm. longa, cum fructu 0.6–1

Fig. 1. Distribution of *Stipa pulchra* and *S. cernua*.

mm. crassa, ad basim et supra nervis pubescens, parte superiore glabra; arista 6–11 cm. longa, flexuosa, scabra vel ad basim pubescens.

Mostly in large clumps, the basal leaves numerous, narrow, usually glaucous; culms several, mostly 60 to 90 cm. tall, middle culm leaves 1.2–2.4 mm. broad. Panicle ample, the basal portion often within the lowermost leaf sheath; panicle branches slender and flexuous or cernous; glumes scarious, pale or reddish purple, long acuminate, the lower 12–19 mm. long, the upper somewhat shorter and broader, 1–1.6 mm. broad, both strictly 3-nerved; lemma 5–10.5 mm. long, 2.2–2.9 mm. broad when unrolled, with caryopsis 0.6–1 mm. thick at maturity, 5- or sometimes 7-nerved, the callus acute, pubescence dense on the callus and on the lower

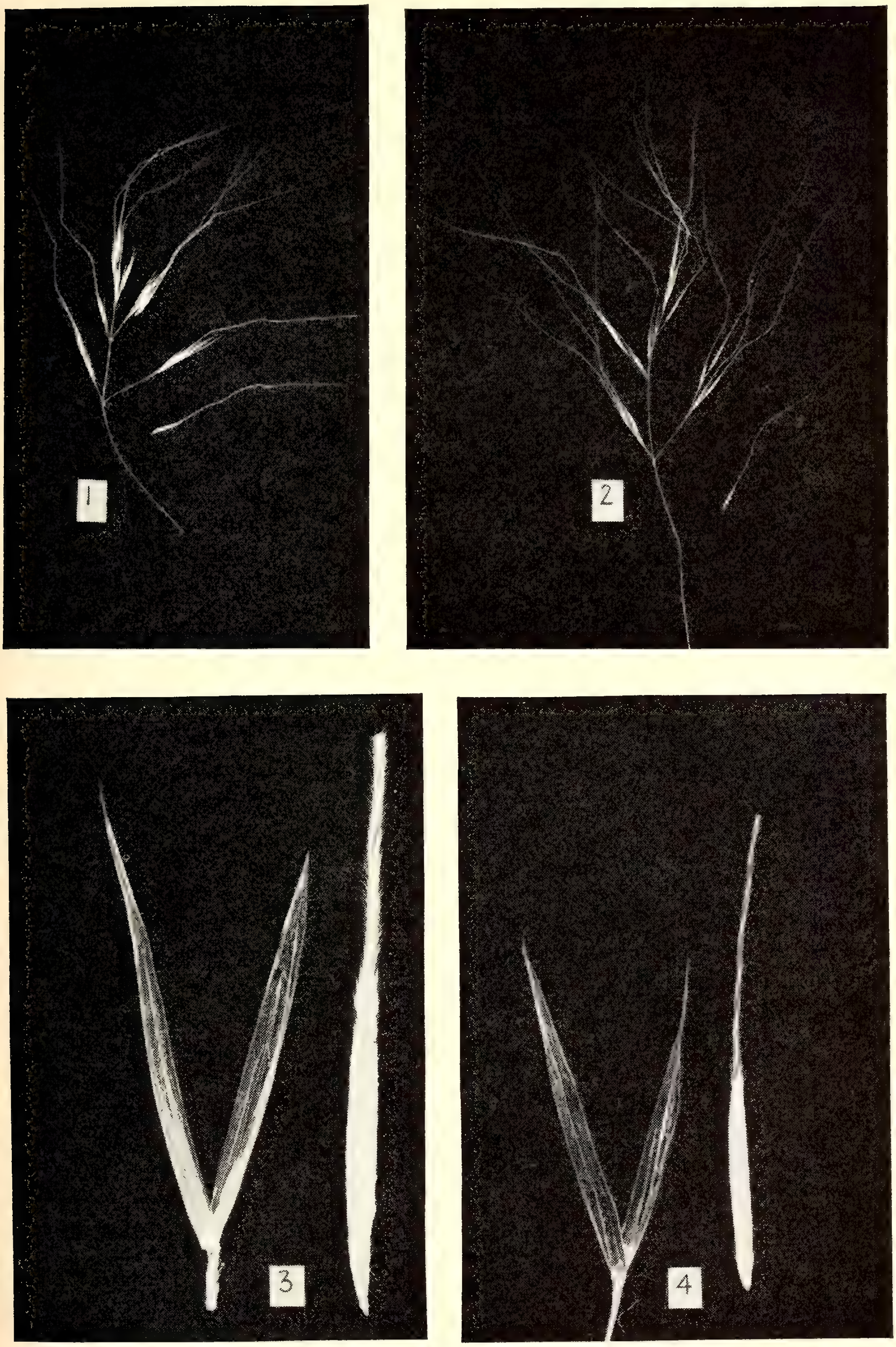

Plate 13. Inflorescence and Florets in Stipa. Fig. 1. *Stipa pulchra* Hitchc., from Berkeley (*Stebbins 2670*), panicle branch × .33. Fig. 2. *S. cernua,* from Santa Barbara County (*Stebbins 2875*), panicle branch × .33. Fig. 3. *S. pulchra,* from Berkeley, glumes and lemma × 3.3. Fig. 4. *S. cernua,* type collection, glumes and lemma × 3.3.

TABLE 1

Comparison of the Principal Characteristics of *Stipa pulchra* and *Stipa cernua*

	S. pulchra	*S. cernua*
Width of next to uppermost culm leaf	2.4–6 mm.	1.2–2.4 mm.
Color of leaves	deep green	glaucous
Character of panicle branches	spreading, or slightly cernuous	slender, flexuous, or cernuous
Length lower glume	15–26 mm.	12–19 mm.
Width upper glume	1.4–2.2 mm.	1.0–1.6 mm.
Number of nerves on upper glume	3–5	3
Length of lemma	7.5–13 mm.	5.0–10.5 mm.
Width of lemma (unrolled)	3.3–4.8 mm.	2.2–2.9 mm.
Number of nerves on lemma	5–9	5–7
Thickness of mature caryopsis including lemma	1.0–1.4 mm.	0.6–1.0 mm.
Pubescence of lemma	throughout, or at base and on nerves to middle or summit	at base and on nerves one-third to four-fifths of way to summit
Length of awn	60–90 mm.	60–110 mm.
Ratio of awn to lemma	5.9–9.8	8.7–14.5
Pubescence of awn below first bend	pubescent	scabrous or slightly pubescent

one-fifth to one-fourth of the body of the lemma, the upper part of the lemma scabrous and with the nerves pubescent one-third to four-fifths of the distance to the summit, lemma usually pale straw- or buff-colored, occasionally purplish, brownish, or blackish; awn 6–11 cm. long, 8.7–14.5 times the length of the lemma, twice bent at maturity, slender and flexuous beyond the second bend, scabrous or short-pubescent below the first bend.

California, from Tehama County south to San Diego County east to the Sierra Nevada foothills, reaching the coast from Monterey southward, and extending up to about 1360 meters (4500 feet) altitude in southern California.

Type. West side of Cedar Mountain Ridge, southeast of Livermore, Alameda County, altitude 400 meters (1300 feet), *G. L. Stebbins, Jr. 2732*, (Herb. Univ. Calif. 641631). The following specimens in the University of California Herbarium are also typical: west of Orland, Glenn County, *Heller 11434;* Nacimiento River, Monterey County, *Davy 7688;* Santa Barbara, *Elmer 3874;* Mount Pinos, Ventura County, *Hall 6426;* Mint Canyon, east of Saugus, Los Angeles County, *Munz 6794;* near Rialto, San Bernardino County, *S. B. & W. F. Parish 2038;* San Bernardino Valley, *Parish 6204, 11257;* near Winchester, Riverside County, *Hall 2921;* Box Springs Mountain, Riverside County, *Hall 2977;* San Diego, *Brandegee 833.*

As mentioned previously, *Stipa cernua* is most closely related to *S. pulchra.* The differences between the two species are sum-

marized in Table 1, and partly illustrated in plate 13. The following may be used as convenient key characters:

Leaves green, the middle culm leaves 2.4–6 mm. broad; lemmas fusiform, with caryopsis 1–1.4 mm. thick at maturity; awn stout and stiff, mostly 7–9 times as long as the lemma .... *S. pulchra*
Leaves somewhat glaucous, the middle culm leaves 1.2–2.4 mm. broad; lemmas slender, with caryopsis 0.6–1 mm. thick at maturity; awn slender, flexuous beyond the second bend, mostly 9–12 times the length of the lemma .... *S. cernua*

The distribution of the two species, as determined by the collections and observations of the writers as well as by the specimens in the University of California Herbarium, is shown in figure 1. It will be seen that they occur together throughout a rather large area, and can often be found growing side by side. In these places they are usually quite distinct, but forms intermediate between them do occur. The writers studied particularly these intermediate plants as found in two localities near San Benito, San Benito County, and found them to be completely sterile or nearly so. Although the surrounding plants of *S. pulchra* and *S. cernua* were producing good seed in abundance, not a single fertile grain was found on any of the intermediates. The latter showed considerable hybrid vigor, often forming clumps much larger than those of the parent species. In the University of California Herbarium there are three specimens of such sterile intermediates: north base of Mount Hamilton, Santa Clara County, *Sharsmith 664A;* Pacific Grove, Monterey County, *Elmer 3507;* Las Flores Canyon, Santa Monica Mountains, Los Angeles County, *Epling* in 1930. Only the latter specimen had anthers with pollen for examination; in it 5 per cent of the pollen grains were large and well filled with cytoplasm, as contrasted with 90–96 per cent in typical *S. pulchra* and *S. cernua.*

The chromosome numbers of the two species are reported elsewhere as $2n = 64$, $n = 32$ for *S. pulchra,* and $2n = 70$, $n = 35$ for *S. cernua* (Stebbins and Love, Am. Jour. Bot. 28: 371–382. 1941). Three of the sterile intermediate plants from San Benito were dug up and transplanted to pots in Berkeley, and their somatic chromosome number was determined as $2n = 67$, indicating that they are actually first generation hybrids between *S. cernua* and *S. pulchra.* Their meiosis will be studied during the coming season.

Except for *S. pulchra, S. cernua* has no close relative among the North American species of *Stipa.* It resembles *S. comata* in its glaucous leaves and long awns, but that species has large, thick lemmas as in *S. pulchra,* and lacks the collar at the apex of the lemma which is found in both *S. pulchra* and *S. cernua.* It is possible that *S. cernua* is related to some of the numerous South American species of *Stipa,* but the present writers have not seen adequate material of any of them to judge their relationships.

College of Agriculture,
University of California, Berkeley,
January, 1941

REVIEWS

The Evolution of Land Plants [*Embryophyta*]. By DOUGLAS HOUGHTON CAMPBELL. Pp. 1–731 with 351 text figures. Stanford University Press. 1940.

This large volume has two main elements. It is a résumé of the author's half century of morphological, chiefly embryological, study; and it is a condensed summary of the work of other writers on the relationships of the higher plants. Of these, the former is the more valuable, which is natural since Dr. Campbell has himself been the foremost contributor to our understanding of the broader lines of the evolution of the land plants. It is as to these broad lines, where the work of the past fifty years has brought confidence in some things and doubt as to others, that this book registers well the present state of science and can serve as a mile post.

The larger part of the book is taken up by the finer classification, to orders, families, in some places to genera. Here the author depends more upon the views of others, and the presentation is distinctly less authoritative. For example, among the ferns, the Eusporangiatae are well presented, but the treatment of the higher Leptosporangiatae is comparatively weak.

In accord with custom, the evidence of paleophytology is treated with respect. This science has of course made progress in various respects. But the reviewer would still recall a remark of Dr. Joseph Hooker. "Amongst the many collections of fossil plants that I have examined, there is hardly a specimen, belonging to any epoch, sufficiently perfect to warrant the assumption that the species to which it belonged can be recognized." Yet, specific characters may petrify better than those of classes. Consider spermatozoids and the embryo-sac. A discussion of the nature and value of evidence would be a valuable introduction to a book of this kind.

Next to its completeness, the most marked characteristic of the book is its lack of dogmatism. Correlated with caution is a tendency to entertain the idea of multiple origin of apparently natural groups, and to admit question, even where affinity seems best established. Two examples: the probable central position of some such plant as *Anthoceros* in the ancestry of Embryophyta is perfectly presented, and the group "Anthocerotes" is made a class, coordinate with Hepaticae and Musci. The latter are treated as probable derived groups, but the derivation seems to be pictured as exceedingly ancient, from primeval Anthocerotes, of which "Of course, the sporophyte . . . must have been much simpler than in any living forms—perhaps comparable to that of such liverworts as *Riccia* or *Sphaerocarpus*." To the reviewer, the stoma, common to *Anthoceros* and many mosses, provides positive proof that their common ancestor, if not exactly *Anthoceros* itself, had at any rate a sporophyte independent enough in its nutrition to have evolved this structure.

As to the angiosperms, polyphylesis is explicitly advocated. The characteristic structure of this group is not seed, nor flower, nor pollen tube, nor trachea; it is the embryo-sac. If the hypothesis of multiple origins means that this structure has been evolved several times independently, it is hard to accept. Even more than the stoma, it requires good evidence of repeated evolution before it is questioned as proof of real affinity.

There are 351 numbered figures, most of which are composed of a considerable number of drawings, largely original and well reproduced. They add materially to the value of the book. The text is a remarkable mine of detailed information. How much there is of this may be shown by the index, which occupies 37 pages of fine print, two columns to the page, and is still incomplete; thus, under "stoma" there is no reference to the text, and under "embryo-sac" there is only one.—E. B. Copeland, Department of Botany, University of California, Berkeley.

Sinopsis de la Flora del Cuzco. Fortunato L. Herrera. Tomo I. Parte Sistematica. Pag. 1–528. Publicado bajo los auspicios del supremo gobierno. Lima, Peru, 4 de Julio, 1941.

This check list of the plants of the Department of Cuzco by the distinguished Peruvian botanist is by far the most complete of several similar works by the same author, the first of which appeared in 1919. It lists 2166 species (with a few varieties) 588 of which are cryptogams, about 250 of these being ferns and fern allies. Even so, the author suggests that probably only about one-half of the species growing within the area have been recorded. The predominant families are Compositae, Gramineae, and Leguminosae.

The names are accompanied, at least for the phaenerogams, by source of publication and citation of specimens. The latter are given in detail, usually including altitude, information which will be invaluable in any study of the flora; habitats, however, are rarely indicated. Often the range of the plant outside of Cuzco, if known, is mentioned; there are some economic notes. An appendix contains descriptions of new species based on the author's collections. There is also a list of native names and their scientific equivalents, and an index to the genera.

In a work of this nature, based of necessity on the literature available—of which there is a good bibliography—there are of course always omissions; on the other hand there are a few additions to the flora of Cuzco. In supplements, which it is to be hoped will be issued from time to time, it would be well to give the source of determination and to indicate where the collections may be consulted in order that identifications may be checked when desired. The work would be more consistently useful, too, if publication citations were always given (which is obviously the intent but they are not infrequently omitted). Most of the typographical errors will easily be corrected; only one mistake in the

presentation of the material has been noted, namely the including of the composite *Orthopappus,* on page 321, in the Melastomataceae.

The author in preparing the work and the Peruvian Government in publishing it have made a meritorious contribution to the scientific study of the rich and useful flora of Cuzco; may there be many more similar endeavors based increasingly on the activities of Peruvian students.—J. F. Macbride, Field Museum of Natural History.

A Flora of Arizona and New Mexico. By Ivar Tidestrom and Sister Teresita Kittell. Pp. xxvi + 897 with frontispiece. The Catholic University of America Press, Washington, D. C., 1941. $5.00.

The flora of Arizona and New Mexico, listing 898 genera and 3975 species, is arranged according to the systems of DeCandolle and Bentham and Hooker with some slight emendations, chief of which is the arrangement of the orders and families in a descending numerical sequence as to the number of cotyledons. Hence the Coniferae with many cotyledons come first and the ferns and fern allies with none appear at the close of the work. The keys are brief and to the point and brief descriptions aid materially in amplifying the keys. There is a general citation of habitat and range accompanying each entity. The work is ambitious and as such is worthy but one cannot read it without a feeling of regret. Much of the advance in botany of the past fifteen years is ignored. Many monographs which have appeared during this time are not alluded to either as to the species accepted or in the synonymy.

The frontispiece is a map of Arizona and New Mexico showing the major rivers and the two thousand foot contour intervals. There are fifteen circles indicating localities but no evident reference to these in the text. On the other hand the table of contents refers to the map as showing the "belts of vegetation." The reason for this confusion is not clear to the reviewer.

The volume is lithoprinted and would have been materially improved by either a little more space between the species or by underlining the species names. As it stands the pages appear crowded and the typography does not invite the reader's attention. In many instances the craftsmanship of both typist and printer is definitely at fault.—Herbert L. Mason.

NOTES AND NEWS

On May 24, 1941, the University of California conferred the honorary degree of doctor of laws on Dr. Willis Linn Jepson, Professor of Botany Emeritus of that institution. The honor is in recognition of Dr. Jepson's contribution to our knowledge of the California flora and his long and successful promotion of forest conservation in the state.

VOLUME VI NUMBER 5

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A WEST AMERICAN JOURNAL OF BOTANY

Contents

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A SYNOPSIS OF THE AMERICAN SPECIES OF CICUTA

Mildred E. Mathias and Lincoln Constance

The water hemlocks are of especial interest because of their poisonous properties, which make them a menace both to livestock and human beings. In a recent paper, Bomhard (1) remarks that, "The extremely toxic character of the underground parts ranks this genus as one of the most virulently poisonous groups of flowering plants native to the North Temperate Zone." Hence, a great deal of space has been devoted to them in agricultural bulletins, some of which have directed considerable attention to the specific differences allegedly discernible in the subterranean portions of the plants. It is the purpose of the present paper to evaluate the characters which have been used to delimit species in the genus, and to propose a somewhat revised taxonomic treatment. Specific descriptions for *Cicuta* will appear in a forthcoming number of "North American Flora."

In their pioneer revision of North American Umbelliferae in 1888, Coulter and Rose (2) referred the known members of the genus in America to three species, the European *Cicuta virosa* L. (with two varieties), *C. Bolanderi* Gray, a plant endemic to the California salt marshes, and *C. bulbifera* L. *Cicuta bulbifera,* easily separable from the other species by virtue of the usually asexual reproduction through the agency of bulblets in the axils of the upper foliage leaves, will not enter into the following discussion. This rather simple picture of the genus was upset the following year by Greene (4), who excluded *C. virosa* from America, and described three additional species from the western United States, *C. occidentalis, C. purpurata,* and *C. vagans.* At the same time, he enunciated his faith in the value of vegetative characters in distinguishing the species of water hemlocks in the following words: "In the few families of plants which are, like the Umbelliferae, preëminently natural, the anthological and carpological characters, whether of genera or of species, are apt to be very slight. But here Nature comes usually to the rescue of the despairing carpological systematist, and gives him good characters for his genera, or for his species, in the vegetative organs. Only by regarding these latter can a man set good limits to species in such a genus as *Cicuta.*"

Again, in November of the same year, he re-emphasized (5) and elaborated this view, as follows: "The fact is well recognized, or should be, by descriptive botanists, that in herbaceous plants of all kinds, characters of the roots or other subterranean organs are of the very best for specific distinctions. Those of pubescence, foliage, and to some extent, of the flower also, are less constant within specific limits than are the peculiarities of the root, when the root happens to have peculiarities, which is however by

Madroño, Vol. 6, pp. 145–176. January 17, 1942.

no means the rule in nature. Most commonly the roots, rhizomes, tubers and other such organs will be much the same throughout the whole group—a long series of species, or even an entire genus. In an order so extremely natural as that of the Umbelliferae, in which the fruits are so similar that plants of the same carpology are sometimes placed in different genera in deference to merely vegetative differences, it would seem altogether unphilosophical to require of the fruit that it furnish specific characters; or, to assume that unless the supposed members if a genus can be distinguished carpologically the species is but one."

Coulter and Rose, in their later treatment of the Umbelliferae (3), accepted two of the three species Greene had described, but judged *C. purpurata* to be conspecific with *C. Douglasii* (DC.) C. & R. They added to the list of species *C. Curtissii,* conspecific with *C. mexicana* which they had already described earlier in the same year. Although they accepted Greene's species, they were not entirely convinced of the validity of the characters he had originally employed in distinguishing them: "We reproduce the above key in the hope that it may be further tested in the field, for with the material at our command we have not been able to follow it fully. While we recognize in Professor Greene's typical material the differences suggested, we do not find them constant. The fleshy thickening of the rootstocks and their direction, as well as the thickness and elongation of the roots, seem to vary with the nature of the substratum, as might be expected." The synoptical key offered by Greene, modified by the inclusion of the species he later described follows.

* Root axis very short, nearly or quite erect, not enlarged, its partitions crowded.

+ Roots all alike, slender fibrous.

C. virosa.

++ Main roots coarse, elongated, fleshy fibrous.

C. Bolanderi, C. occidentalis, C. purpurata, C. frondosa, C. arguta, C. Sonnei.

+++ Main roots oval or oblong, fleshy tuberiform.

C. maculata, C. bulbifera, C. subfalcata.

** Rhizomatous species; the root axis greatly enlarged, horizontal, only partly or not at all subterranean, emitting fibrous roots from beneath.

C. vagans, C. californica, C. grandifolia, C. dakotica.

Incapable of placement in this scheme are the three following species, also described by Greene: *C. valida,* "stature of the plant and its underground parts not known"; *C. fimbriata,* described only from the foliage; *C. ampla,* "known to me only in the fruiting summit of a single plant."

Explanation of the Figures. Plate 14.

Plate 14. Fruits of Cicuta. Longitudinal view (× 6.5) and cross section (× 9.5). Figs. 1, 2, *C. Bolanderi;* 3, 4, *C. virosa;* 5, 6, *C. mexicana;* 7, 8, *C. Douglasii;* 9, 10, *C. Victorinii;* 11, 12, *C. mackenzieana;* 13, 14, *C. maculata.*

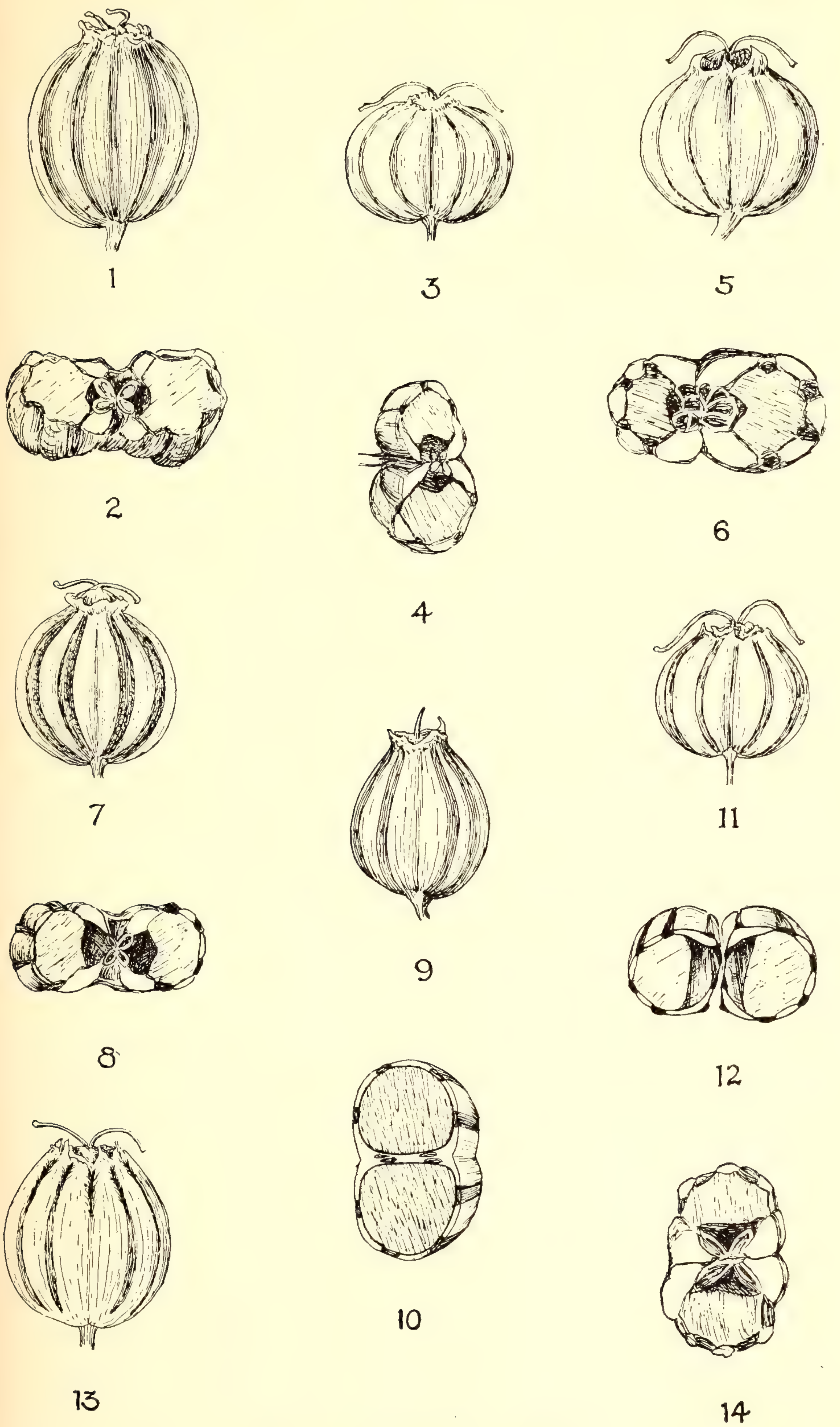

PLATE 14. FRUITS OF CICUTA.

Illustrating their scepticism of the very foundation of Greene's classification, Coulter and Rose proceeded to base their own key on their observation that the "species seem to be best grouped primarily by their oblong or orbicular fruits, further separation being made upon differences in the fruit ribs and in the foliage." Greene, however, seems not to have been at all discouraged and described *C. grandifolia* in 1907, and *C. frondosa, C. subfalcata, C. dakotica, C. arguta, C. valida, C. Sonnei, C. fimbriata* and *C. ampla* in 1912. *Cicuta cinicola* A. Nels. was added from Idaho, also in 1912, and recently *C. mackenzieana* Raup has been described from northern Canada and *C. Victorinii* Fernald from the mouth of the St. Lawrence River. Authors of manuals and floras have not been prone to accept Greene's second deluge of segregates, but have admitted *C. occidentalis* or *C. vagans* or both to their treatments of the appropriate areas.

In preparing a revision of this genus for our account of the Umbelliferae in the "North American Flora," we have had occasion to re-examine the material on which Greene based his conclusions. We are in agreement with him that *Cicuta virosa* is to be excluded from North America, although its relationship to *C. mackenzieana* appears to be rather close. We question the whole thesis that the underground parts of the water hemlocks afford specific characters, at least of the nature noted by Greene, and believe that they are so susceptible of modification in relation to soil composition and fertility, and especially to soil aëration, as to be essentially useless in this connection. Furthermore, we are unable to attach sufficient importance to the degree of leaf-division to warrant the retention of *C. californica* as distinct from *C. Douglasii,* and find that Coulter and Rose's distinction between "oblong" and "orbicular" fruits sometimes breaks down on the same plant. The diagnostic value of leaf-venation as a means of distinguishing *Cicuta* from other umbelliferous genera, and also for separating individual species in the former genus, has been stressed recently by Bomhard (1). She distinguishes *C. californica* from the other species by the fact that the secondary veins of the leaflets are directed at the marginal teeth, rather than at the sinuses between them. Our studies, however, have not enabled us to find any marked difference in this entity, which would warrant its continued retention as a species.

On the other hand, characters of the fruit, especially its compression, the proportion between the dorsal and lateral ribs, their relation to the intervals, and the nature of the oil tubes and the seed do seem to enable us to distinguish natural species in the genus. Our treatment, admits the following species for North America: *C. Bolanderi, C. mexicana, C. Douglasii, C. mackenzieana, C. maculata, C. Victorinii* and *C. bulbifera.* All of the species proposed by Greene will thus be relegated to the synonymy which they appear richly to deserve.

TAXONOMIC TREATMENT

CICUTA L. Sp. Pl. 1: 255. 1753. *Cicutaria* Lam. Fl. France 3: 445. 1778. *Keraskomion* Raf. New. Fl. Amer. 4: 21. 1836. Type species: *Cicuta virosa* L.

Axils of the leaves not bulbiferous.
  Fruit constricted at the commissure; lateral ribs about equalling the dorsals in surface display.
    Oil tubes large (pl. 14, figs. 2, 6); seed oily, evidently channeled under the tubes.
      Ribs narrower than the oil tubes: plants of Pacific Coast salt marshes .... 1. *C. Bolanderi.*
      Ribs broader than the oil tubes; plants of coastal eastern and southeastern United States and eastern Mexico .... 2. *C. mexicana.*
    Oil tubes small (pl. 14, figs. 8, 12); seed less oily, unchanneled or only slightly channeled under the tubes.
      Fruit oval to orbicular, at least as long as broad, 2–4 mm. long, 2–3 mm. broad; rays 12–20, 2–6 cm. long; pedicels 3–8 mm. long .... 3. *C. Douglasii.*
      Fruit elliptical, conspicuously broader than long, 1.5–2.2 mm. long, 2–3 mm. broad; rays 7–14, 7–8 cm. long; pedicels 7–12 mm. long .... 4. *C. mackenzieana.*
  Fruit not constricted at the commissure; lateral ribs much broader than the dorsal in surface display.
    Leaflets coarsely serrate to incised; fruit oval to orbicular, rounded at apex and base; lateral ribs prominent, about equalling the intervals .... 5. *C. maculata.*
    Leaflets finely serrate; fruit ovate, narrowed toward apex, cordate at base; lateral ribs obscure, much narrower than the intervals .... 6. *C. Victorinii.*
Axils of the leaves bulbiferous .... 7. *C. bulbifera.*

1. CICUTA BOLANDERI Wats. Proc. Amer. Acad. 11: 139. 1876.

Type locality. Suisun, Solano County, California, in salt marshes, *Bolander.*

Distribution. Salt marshes of central and southern California.

Representatives. *Davy 4106, 6668, 6789, 6877; Heller 7541.*

2. CICUTA MEXICANA Coult. & Rose, Proc. Wash. Acad. 1: 145. (January) 1900. *C. maculata* L. *sensu* Hemsl. Biol. Centr.-Amer. Bot. 1: 566. 1879–81, not *C. maculata* L. 1753. *C. Curtissii* Coult. & Rose, Contr. U. S. Nat. Herb. 7: 97. (December) 1900. *C. maculata* var. *Curtissii* Fern. Rhodora 41: 439. 1939.

Type locality. Coatzacoalcos, Isthmus of Tehuantepec, Vera Cruz, *Chas. L. Smith 1161.*

Distribution. New Jersey to Florida, south and west to Tamaulipas, Nuevo Leon and Vera Cruz.

Representatives. *Curtiss 6845; Heller 1165; Palmer 445; Pringle 10,804.*

3. CICUTA DOUGLASII (DC.) Coult. & Rose, Contr. U. S. Nat. Herb. 7: 95. 1900. *Sium Douglasii* DC. Prodr. 4: 125. 1830. *Cicuta maculata* L. *sensu* Hook. & Arn. Bot. Beechey Voy. 142. 1841, not L. 1753. *C. californica* Gray, Proc. Amer. Acad. 7:

344. 1867. *C. crassifolia* Nutt. Rept. Wilkes Exped. 17: 316. 1874. *C. virosa* var. *californica* Coult. & Rose, Rev. N. Amer. Umbel. 130. 1888. *C. occidentalis* Greene, Pittonia 2: 7. 1889. *C. occidentalis* f. *frondosa* Greene, *op. cit.* p. 7. *C. purpurata* Greene, *op. cit.* p. 8. *C. vagans* Greene, *op. cit.* p. 9. *C. grandifolia* Greene, Leafl. Bot. Obs. 2: 124. 1909. *C. Douglasii* var. *occidentalis* Jones, Bull. Univ. Mont. Biol. ser. 15, 42. 1910. *C. Sonnei* Greene, Leafl. Bot. Obs. 2: 239. 1912. *C. subfalcata* Greene, *op. cit.* p. 237. *C. frondosa* Greene, *op. cit.* p. 236. *C. valida* Greene, *op. cit.* p. 238. *C. fimbriata* Greene, *op. cit.* p. 240. *C. cinicola* A. Nels. Bot. Gaz. 54: 141, fig. 1. 1912. *C. occidentalis* f. *californica* Wolff ex Engl. Pflanzenr. 4^{228}: 90: 82. 1927. *C. occidentalis* f. *oregonensi-idahoensis* Wolff, *op. cit.* p. 82. *C. occidentalis* f. *arizonensis* Wolff, *op. cit.* p. 82. *C. occidentalis* f. *wyomingensis* Wolff, *op. cit.* p. 82.

Type locality. "In America boreali-occid.," *Douglas.*

Distribution. Alberta and Montana to western Alaska, south to California, New Mexico, Arizona and Chihuahua.

Representatives. *Baker 655; Brown 501; Cusick 2556, 2779; Heller 7174; Nelson & Macbride 1315; Townsend & Barber 57.*

4. Cicuta mackenzieana Raup, Journ. Arn. Arb. 17: 279, pl. 197. 1936.

Type locality. Sandy margin of a lagoon near the south shore of Lake Athabaska about 1.5 miles west of Ennuyeuse Creek, Canada, August 25, 1935, *Raup 6976.*

Distribution. Hudson Bay to the Mackenzie Basin.

Representatives. *Macoun 79,261; Raup 6764, 6964.*

5. Cicuta maculata L. Sp. Pl. 1: 256. 1753. *C. maculata* Lam. Encycl. 2: 2. 1786. *C. virosa* var. *maculata* Coult. & Rose, Rev. N. Amer. Umbel. 130. 1888. *C. dakotica* Greene, Leafl. Bot. Obs. 2: 237. 1912. *C. arguta* Greene, *op. cit.* p. 238. *C. ampla* Greene, *op. cit.* p. 241. *C. dakotica* var. *pseudovirosa* Lunnell, Amer. Midl. Nat. 4: 486. 1916. *C. dakotica* var. *pseudomaculata* Lunell, *op. cit.* p. 486.

Type locality. Virginia, *Kalm.*

Distribution. Prince Edward Island and Quebec to North Carolina and Tennessee, west to North Dakota and Texas.

Representatives. *Fernald & St. John 1141; M. L. Grant 3238; Heller 1002; Lindheimer 615.*

6. Cicuta Victorinii Fern. Rhodora 41: 441, pl. 561, figs. 1–2. 1939.

Type locality. Tidal flats of the St. Lawrence River, Quebec: "greves intercotidales, Cap Rouge pres du Pont de Quebec, 9 aout 1922," *Victorin 15,479.*

Distribution. Known only from the estuary of the St. Lawrence River, Quebec.

Representatives. *Fernald & Long 24,249; Victorin 15,480.*

7. Cicuta bulbifera L. Sp. Pl. 1: 255. 1753. *Cicutaria bulbifera* Lam. Encycl. 2: 3. 1786. *Keraskomion bulbiferum* Raf. New. Fl. 4: 21. 1836.

Type locality. Virginia, Canada, *Clayton.*

Distribution. Newfoundland and Quebec to Delaware and Pennsylvania, west to British Columbia and Oregon.

Representatives. *Cusick 2966; Heller & Heller 551; Sandberg, MacDougal & Heller 789.*

Department of Botany,
University of California, Berkeley,
May, 1941.

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4. Greene, E. L. Pittonia 1: 271–272. 1889.
5. ————. Pittonia 2: 1–11. 1889.

GREAT BASIN PLANTS—VI. NOTES ON GENTIANA

Bassett Maguire

Continuing the series of minor papers discussing plants of the Great Basin, these notes are concerned with the delineation of a newly recognized geographical population of *Gentiana calycosa,* and the confirmation of a range extension of *G. barbellata.* All specimens herein cited are on deposit at the Intermountain Herbarium. The United States Forest Herbarium, Washington, D. C., is designated by the symbol USFH.

Gentiana barbellata Engelm. The following collection confirms the queried inclusion of the species within the Utah range by Tidestrom. Utah. Sanpete County: frequent, stony, steep, west-facing slopes, summit of Horse Shoe Mountain, South Peak, 12,000 feet, Manti National Forest, August 11, 1940, *Maguire 20059.*

Gentiana calycosa Griseb. subsp. **typica** nom. nov., *G. calycosa* Griseb. in Hook. Fl. Bor. Amer. 2: 58. 1838. *Dasystephana obtusiloba* Rydb., Bull. Torr. Bot. Club 40: 464. 1913. *D. monticola* Rydb. *l.c.*

Gentiana calycosa Griseb. subsp. **asepala** subsp. nov. Herbae perennes parvulae; caulibus decumbentibus, 5–10(12) cm. longis; foliis ovatis vel ovato-ellipticalibus 1.0–1.5(1.7) cm. longis; floribus solitariis; corollis 3–4 cm. longis; calicibus membranaceis, graviter incisis, lobis obsoletis vel inconspicuis subulatisque, rare excedentibus 1–1.5 mm.

Low perennial herbs; stems decumbent, 5–10(12) cm. long; leaves ovate to ovate elliptical 1.0–1.5(1.7) cm. long; flowers solitary, corolla 3–4 cm. long; calyx membranaceous, character-

istically deeply incised on two sides, lobes obsolete, or inconspicuous and subulate, rarely more than 1–1.5 mm. long.

Type. Meadows about seepage areas, southeast slopes, saddle west of Mount Agassiz, 11,500 feet elevation, Uinta Mountains, Duchesne County, Utah, August 15, 1933, *B. Maguire, Ruth Maguire, & A. G. Richards, 4225.*

Specimens examined. IDAHO. Custer County: meadow, Steward Canyon, 8000 feet, Lemhi National Forest, July 17, 1931, *S. L. Jacobs 90* (USFH, 65577). Idaho County: Floyd Meadow, 6000 feet, Idaho National Forest, August 8, 1930, *C. Gray CG57* (USFH, 67318). Lemhi County: Allen Lake Meadow, 8000 feet, Salmon National Forest, September, 1930, *A. H. Wheeler 70* (USFH, 84421). Valley County: Nameless Meadow, 6500 feet, Fayette National Forest, September 1, 1930, L. N. Wellman 18 (USFH, 67628) mixed with *G. affinis.* Blaine County: alpine slopes, base Devil's Bedstead, Sawtooth Range, 8000 feet, July 28, 1936, *J. W. Thompson 13549.* Custer County: damp, springy soil, Toxaway Lake, 10 miles west-southwest of Obsidian, Sawtooth Mountains, 8500 feet, August 8–11, 1937, *C. L. Hitchcock & J. S. Martin 5749;* Mount Hyndman, August 11, 1939, *Ray J. Davis 1704.* NEVADA. Elko County: meadow, Ruby Ranger Station, 6000 feet, Humboldt National Forest, June 28, 1930, *L. E. McKenzie 28* (USFH, 64353). UTAH. Summit County: meadows, Lily Lake, 10,500 feet, 3 miles west of Bald Mountain, Uinta Mountains, August 14, 1933, *Maguire et al. 4224;* bogs, west shore Henry's Fork Lake, 10,850 feet, Uinta Mountains, August 4, 1936, *Maguire et al. 14381.* Uintah County: wet place under spruce, south base of Liedy Peak, 10,000 feet, Uinta Mountains, August 21, 1939, *Maguire 17678.* Specimens from Oregon intermediate to subsp. *typica* are: Baker County: Antony Lakes Region, Blue Mountains, 7100 feet, July 23, 1936, *J. W. Thompson 13430.* Wallowa County: meadows, Mirror Lake, Eagle Cap Peak, Wallowa Mountains, 7500 feet, September 24, 1938, *C. W. Sharsmith 3971.*

The subspecies of *Gentiana calycosa* may be distinguished as follows:

Subspecies *asepala*	Subspecies *typica*
Stems conspicuously decumbent, 5–10 (12) cm. long.	Stems erect, or slightly decumbent at the base, (8)10–20 cm. long.
Leaves 1.0–1.5(1.7) cm. long.	Leaves (1.5)2.0–3.0 cm. long
Corollas 3–4 cm. long.	Corollas 3.5–4.5(5.0) cm. long.
Calyx membranaceous, deeply incised, lobes obsolete, or inconspicuous and mostly subulate, 1.0–1.5(2.0) cm. long.	Calyx membranaceous mainly in the sinuses, not at all or rarely incised, lobes foliaceous, ovate, elliptic, or lanceolate, 5–10(15) mm. long.
A Great Basin-Intermountain race, apparently confined to Utah, Nevada and Idaho. Intermediate plants are known from eastern Oregon.	The population of the Rocky Mountains and the Sierra Nevada, extending into Alberta and British Columbia.

The smaller, frequently almost procumbent subspecies is primarily and sharply set off from the typical population by the critical calyx distinction. It further occupies a clear-cut southern geographical range. Interestingly there is considerable similarity in its calyx characters to those of *Gentiana Parryi* of the southern Rocky Mountains, suggesting that this latter species might be likewise a southern, but more complete segregate of *G. calycosa* subsp. *typica*.

Intermountain Herbarium,
Utah State Agricultural College, Logan.
May 11, 1941

ARNICA IN ALASKA AND YUKON

Bassett Maguire

For some time the manuscript of a monograph of the genus *Arnica* has been completed, and is awaiting publication. During the course of the work the writer had been asked by Dr. Eric Hultén to contribute the account of *Arnica* for the "Flora of Alaska and Yukon," now appearing in parts. Because of the immediacy of the needs of Dr. Hultén, and because appearance of the "monograph" does not, in the near future, seem probable, the following new entities, new names, and new combinations, for the most part, are herewith extracted from that study. Only the principal synonomy is given for the new names and combinations. Sequences and numbering of entities is that employed in the treatment prepared for Hultén's "Flora."

1a. Arnica alpina (L.) Olin subsp. **angustifolia** (Vahl) comb. nov. *A. angustifolia* Vahl, Fl. Dan. 3. 1816; *A. alpina* (L.) Olin var. *angustifolia* Fernald, Rhodora 36: 96. 1934.

1b. Arnica alpina (L.) Olin subsp. **attenuata** (Greene) comb. nov. *A. attenuata* Greene, Pittonia 4: 170. 1900.

1c. Arnica alpina (L.) Olin subsp. **tomentosa** (Macoun) comb. nov. *A. tomentosa* Macoun, Ottawa Nat. 13: 168. 1899; *A. tomentosa* Greene, Pittonia 4: 168. 1900; *A. pulchella* Fernald, Rhodora 27: 18. 1915.

2a. Arnica louiseana Farr subsp. **frigida** (Meyer) comb. nov. *A. frigida* Meyer ex Ilijin, Trav. Musc. Bot. Acad. Sc. U.S.S.R. 19: 112. 1926; *A. nutans* Rydb. N. Am. Fl. 34: 328. 1927; *A. Sancti-Laurenti* Rydb., N. Am. Fl. 34: 328. 1927.

a. Var. **genuina** nom. nov. *A. frigida* Meyer ex Ilijin *l.c.*

b. Var. **Mendenhallii** (Rydb.) comb. nov. *A. Mendenhalli* Rydb. N. Am. Fl. 34: 329. 1927.

c. Var. **brevifolia** (Rydb.) comb. nov. *A. brevifolia* Rydb. N. Am. Fl. 34: 329. 1927.

d. Var. **illiamnae** (Rydb.) comb. nov. *A. Illiamnae* Rydb. N. Am. Fl. 34: 331. 1927.

e. Var. **pilosa** var. nov. Caulibus 5–10 (15) cm. altis, foliis 2.0–4.0 (5.0) cm. longis, denticulatis; herbaceo exigue piloso; pedunculis dense pilosis; pericliniis densus subflavis lanato-pilosis; capitulis nutantibus, aut plus frequenter erectis; acheniis glabratis, aut plus frequenter sparse super hirsutis.

Type. Igloo Creek, McKinley National Park, July 11, 1932, *Joseph Dixon 29*. Deposited in the Herbarium of the University of California; isotype at the United States National Herbarium.

This population, seemingly confined to the Mount McKinley area, is strongly marked. Plants with erect heads closely resemble specimens of *A. alpina* subsp. *tomentosa,* to which indeed they had mostly been referred. The basally or entirely glabrous achenes, and the yellowish periclinial pubescence seem, however, definitely to relate the McKinley plants to *A. louiseana.*

4a. Arnica cordifolia Hook. subsp. **genuina** nom. nov. *A. cordifolia* Hook., Fl. Bor. Am. 1: 33. 1834.

a. Var. **pumila** (Rydb.) comb. nov. *A. pumila* Rydb. Mem. N. Y. Bot. Gard. 1: 433. 1900.

5a. Arnica Chamissonis Less. subsp. **genuina** nom. nov. *A. Chamissonis* Less., Linnaea 6: 238. 1831.

a. Var. typica Regel, Suppl. Ind. Sachal 151. 1864.

b. Var. **interior** var. nov. Foliis inferioribus plus petiolatis, 2.5–3.5 cm. latis; capitulis 15–18 mm. latis; corollis disci 7–8 (10) mm. longis.

Type. Palliser, July 30, 1906, *S. Brown 770*. Type deposited in the Gray Herbarium; isotypes at United States National Herbarium, New York Botanical Garden, Academy of Natural Sciences, Philadelphia, Missouri Botanical Garden.

The variety *interior* is the common inland form, and by far the greatest population, extending southward into Canada. It differs from, although completely intergrading with, the maritime var. *typica* Regel in having mostly petiolate rather than sessile lower cauline leaves, smaller heads (18–20 cm. broad in var. *typica*), and shorter disc flowers (9–11 mm. long in var. *typica*).

6a. Arnica amplexifolia Rydb. subsp. **genuina** nom. nov. *A. amplexifolia* Rydb. Mem. N. Y. Bot. Gard. 1: 434. 1900; *A. amplexicaulis* Nutt. Trans. Am. Phil. Soc. n.s. 7: 408. 1841, non Wall. 1837.

a. Var. **borealis** (Rydb.) comb. nov. *A. borealis* Rydb. N. Am. Fl. 34: 351. 1927.

6b. Arnica amplexifolia Rydb. subsp. **prima** subsp. nov. Rhizomate longo, 2–3 mm. diametro, sparse radicellis vestito; caule 4.0–7.5 dm. alto, simplici, gracili, non furcato; foliis caulinis 5–7 jugis, elliptico-lanceolatis remote serrato-dentatis, 2–3 cm. latis, 6–8 cm. longis, capitulis 1–3, hemispherico-campanulatis, 12–15 mm. altis, pericliniis moderatis pilosis, longi stipitato-glandulosis.

Type. Kodiak, August 28, 1867, *A. Kellogg 231.* Deposited at the Academy of Natural Sciences, Philadelphia; isotypes at Gray Herbarium, United States National Herbarium, Missouri Botanical Garden, and a specimen of questionable authenticity at the New York Botanical Garden. The subspecies occurs only in maritime Alaska and on the Alaskan islands.

This subspecies may be separated from subsp. *genuina* by the following key:

Cauline leaves 5–7 pairs, the lower 2 or 3 pairs petioled, margins only inconspicuously dentate-serrate; mostly with 1–3 heads; plants of the Alaskan Coast region and islands . . . *A. amplexifolia* subsp. *prima*

Cauline leaves 5–12 pairs, mostly all sessile, margins mostly conspicuously sharply serrate-dentate; mostly with 5(3)–7(9) heads; occurring from Alaska to California and Montana . . . . *A. amplexifolia* subsp. *genuina*

This clearly distinct race is interesting and important. It shows much similarity to *Arnica Chamissonis* and *A. amplexifolia* subsp. *genuina,* in leaf character and pubescence, and particularly resembles the former in the tendency to produce long unappendaged rhizomes. Indeed the intermediate characters of this rather small group of plants strongly suggest the possible derivation of the remainder of the subgenus *Chamissonis* through *A. Chamissonis.* Or, again, this entity of primarily insular distribution might prove to be hybrid between *A. amplexifolia* and *A. Chamissonis.*

8a. Arnica Lessingii Greene subsp. **genuina** nom. nov. *A. Lessingii* Greene, Pittonia 4: 167. 1900.

8b. Arnica Lessingii Greene subsp. **Norbergii** Hultén and Maguire. Caulibus 2.5–3.5 dm. altis, foliis caulinis 5–6 jugis, (3) 5–8 cm. longis, 1–1.5 cm. latis, ellipticis, acutis, herbacio sparse aut moderate moniliformo-pilosis.

Type. Orca, August 14, 1937, *I. L. Norberg.* Deposited at Lund; isotype at Utah State College.

So striking and distinctive are the type specimens in height and in the numerous pairs of narrower cauline leaves (3–4 pairs in subsp. *genuina*) that the authors venture to designate them as a subspecies. Were it not for approaching intermediates (*Hultén 8144* from Juneau) they should be tempted to propose these plants as representing a separate species. A somewhat similar plant, *Anderson 2A 375* from Mendenhall, is questionably referred here. It may be found that the Norberg specimens represent sole disparities and hence are best relegated to varietal rank.

Intermountain Herbarium,
Utah State Agricultural College,
Logan, Utah.

A COMPARISON OF THE EMBRYOGENY OF PICEA AND ABIES

J. T. Buchholz

Picea Smithiana Boiss. The embryogeny of *Picea Smithiana* Boiss. was observed in the spring of 1936 in trees planted on the campus of Stanford University. Though it was impossible to follow the entire embryogeny, the stages of suspensor formation were observed in considerable detail and this account will serve to present more fully than heretofore the differences between the suspensor of a spruce and that of a fir, which will also be described in greater detail.

Picea Smithiana is a species introduced into cultivation more than a century ago from southern Asia. Its native region is given as Afganistan and the Himalayas. Its embryogeny appears to be very similar to that of *Picea Abies* (L.) Karst., (*P. excelsa*), and several American spruces which the writer has examined previously and is probably typical for the genus *Picea*.

The development of the proembryo was not observed. Miyake (7) gave us a description of the proembryo of *Picea excelsa* in all stages. Another record in the form of drawings made nearly a century ago by Schacht (8) describing the late stages in the proembryo of *Picea glauca* (Moench) Voss has been generally overlooked because it was given under the name *Abies alba* Michx., a synonym of *Picea glauca*.

Four tiers of four cells each are found in the proembryo. *Pinus* and nearly all genera of Pinaceae (Abietineae) have this same type of proembryo (2, 4). The uppermost tier of cells is incompletely surrounded by walls, and these four nuclei soon disappear. The uppermost tier of walled cells is the rosette, the name given to this structure by Schacht. Below this is a tier of suspensor cells which elongate in unison, and push the embryonic tier forward into the female gametophyte. The embryonic tier divides very soon after the elongation of the suspensor has begun.

This precocious division of the embryonic cell to form an additional tier is a feature wherein the spruce differs from the fir. In *Abies* the tier of embryonic cells may remain undivided for a considerable period, during which the suspensor becomes very long.

Figure 1 shows the earliest stage of the embryo of *P. Smithiana* obtained from dissections. The division of the embryonic cells into two tiers has already taken place, although the cells of the suspensor tier have only become elongated in the ratio of about 6 : 1. Figure 2 shows a later stage in which the four lowest cells have divided again, so that three cells are now replacing each of

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Explanation of the Figures. Plate 15.

Plate 15. Successive Stages in Embryogeny of Picea Smithiana. Figs. 1–6, × 60 (fig. 2 an optical section). s = primary suspensor, e = tier of embryonic cells; e_1, e_2, e_3 = successive tiers of embryonal tubes that constitute secondary additions to the suspensor system.

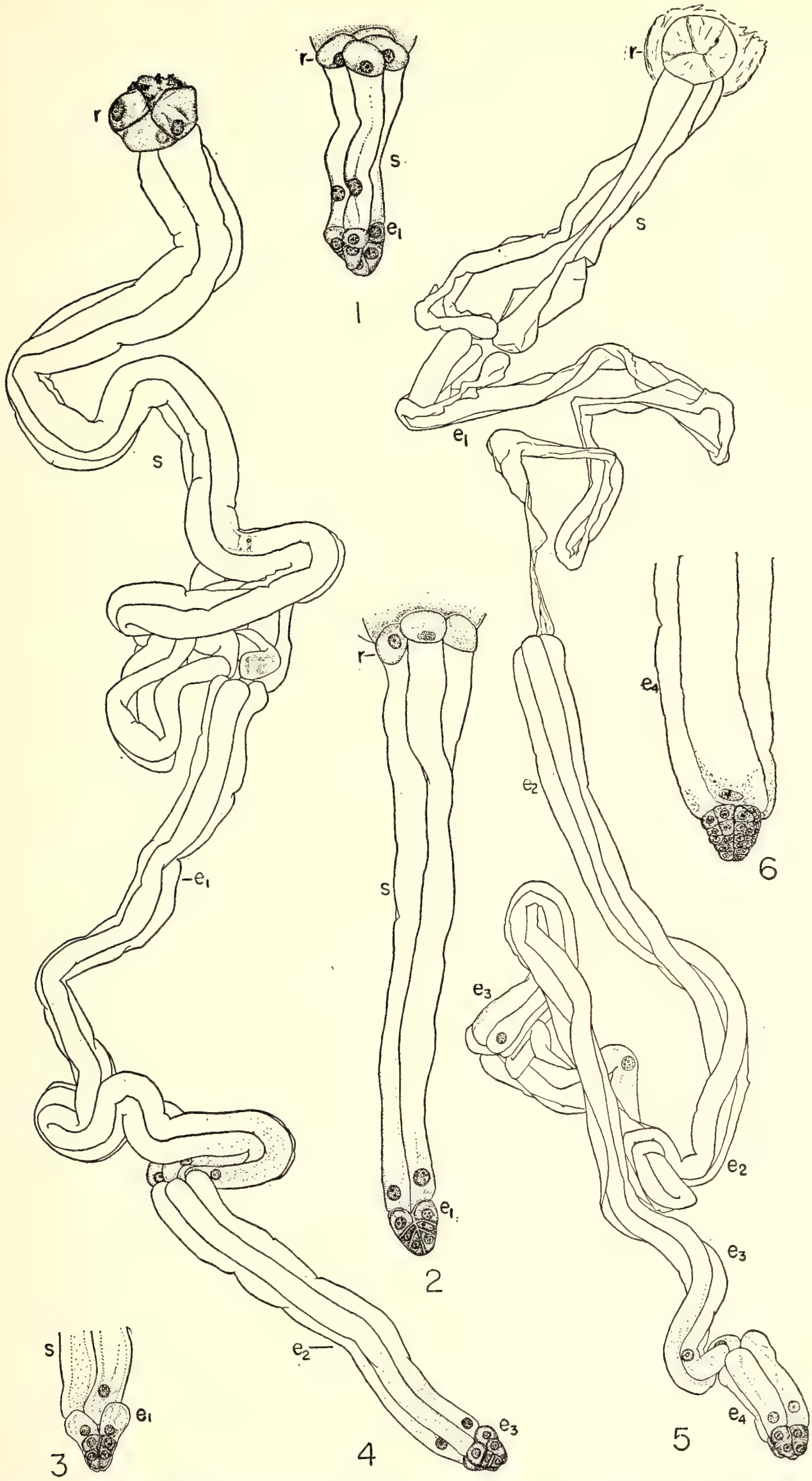

PLATE 15. SUCCESSIVE STAGES IN EMBRYOGENY OF PICEA SMITHIANA.

the four original embryonic cells as found in the lowest tier of the proembryo. In figure 3, the tier of cells next to the suspensor is beginning to elongate. This elongation is succeeded by that of the next tier, and by that of adjacent cells in tiers still to be added by the division of the terminal tier. Figure 4 shows a suspensor system in which the *s*, e_1 and e_2 tiers have elongated. For convenience the first tier is called the primary suspensor tier and the series of cells that elongate in successive 4-celled tiers may be designated as embryonal tubes e_1, e_2, e_3, and e_4. The e_4 is the last tier to be added to this regular succession before the terminal group of embryonic cells becomes more actively meristematic to increase greatly the number of cells in the entire embryo. The tiers that elongate subsequently to add the secondary suspensor come off in more irregular groups of cells. Figure 5 shows this stage in an embryo which has produced the e_4 sections of the suspensor. It is likely that the e_3 tier may at times be the last regular tier and in subsequent stages, the embryonal tubes lose their symmetry, become interlocked and more irregular in their elongation as they build up a massive secondary suspensor.

The writer can find no essential difference in appearance between the tiers *s*, e_1, e_2, e_3, etc., in *Picea.* There is probably no valid reason for making the distinctions implied by the names primary suspensor *s* and embryonal tubes of the successive orders e_1, e_2, etc., but this somewhat arbitrary designation is retained for the sake of uniformity and because it does seem to make a difference when compared with other genera of conifers. Figure 6 shows an embryo of more than 30 cells in which about 8 cells are adjacent to e_4 tier, which will elongate to form a much more massive addition to the suspensor.

The early suspensor system is, therefore, segmented and made up of four or five 4-celled and regularly tiered tubes. *Picea* has a rosette in which nuclei remain visible for some time, but the nuclei in the rosette disappear without undergoing division about the time the nuclei of the primary suspensor cells disintegrate. The successive suspensor cells collapse in the order of their age so that their remains and those of the rosette are sometimes difficult to find. The cells in the successive suspensor segments become about 20 to 30 times as long as their original diameter before the nuclei disappear and the suspensor elements collapse.

In *Picea,* simple polyembryony prevails. The fertilization of several eggs may give rise to several embryos which compete with each other, but the product of a single fertilized egg does not split up into several embryos, as in *Pinus, Cedrus* and *Tsuga.* The single embryo which survives usually has 8 to 10 cotyledons.

PICEA OMORIKA (Pancic) Purkyne. The Siberian spruce was examined a number of years ago from trees planted at the Arnold Arboretum. The stages obtained were somewhat older than those described above, but the succession of tiered suspensor elements

could also be observed in this species. Since the oldest elements had collapsed, it was not possible to be certain that e_4 was the last 4-celled tier that had elongated, though an e_3 tier could be recognized. In respect to the suspensor system and simple polyembryony, this Siberian spruce agrees with other spruces. The embryo as found in the mature seed of *Picea Omorika* had 5 to 6 cotyledons.

Abies venusta (Dougl.) K. Koch. The material for a study of the embryogeny of the Santa Lucia fir came from trees planted on the campus of Stanford University. The trees in the Santa Lucia mountains, their native region, were found to be too inaccessible and too far removed from a laboratory. Those on the grounds of Stanford University could be studied within an hour after collection. Their advantages were the early fertilization and the fact that the schedule of development fitted more conveniently into a research program which included other conifers.

The proembryo of no species of *Abies* has been adequately investigated. Miyake (6) observed only the free nuclear stages and Hutchinson (5) added a few stages in a study of *Abies balsama.* Hutchinson's account, especially his statement: "the proembryo of *Abies* ordinarily consists of eight cells only, in two tiers" is misleading and might leave one with the impression that *Abies* has a program in its proembryo which differs from other conifers. Actually it is very similar to *Pinus* (4) and *Picea* (7) in its early stages.

There is no doubt that the proembryo is the same as that described above for *Picea* except that the embryonic tier does not divide immediately. This tier divides only after considerable elongation of the suspensor tier.

The three tiers of cells—rosette, suspensor, and embryonic—are still present and undivided in *A. venusta* when the suspensor has elongated considerably. This is shown in figure 7 and in figure 8. Thus it is clear that there is really no serious hiatus in our knowledge concerning the proembryo of *Abies.* An opaque deposit has appeared over the rosette and all traces of the tier of relict nuclei have disappeared. In figure 9 each cell of the lowest tier of embryonic cells has divided so that this quartette of cells has now formed an octette arranged in two tiers. In figure 10 each of the original quartette of cells is represented by a progeny of four cells. The details of the embryo in figure 10 are shown better under higher magnification in two planes of focus in figures 10a and 10b.

The pointed tip of the embryo has a very thick hyaline wall which is also shown best in figures 10a and 10b. The pointed ends are very close together at first (figs. 7–9), become separated with the growth and lateral enlargement of the embryo, and remain as tiny projecting knobs that serve to identify the four derivative cell groups. These hyaline tips may be seen in successive stages

shown by figures 11, 16, 17, and are obscurely recognizable in figure 18, in which the embryo has several hundred cells.

Sometimes the vertical rows do not contribute equally to the embryonic mass. Figures 12 and 13 show conditions in which inequalities have appeared in the development of the progenies of the 4 original embryonic cells. These do not show the small knobs that are seen in figure 17. In the latter, and in figure 18, the evidence is fairly conclusive that the cell progenies of the four original embryonic cells have contributed equally to the embryonic tissue.

Simple polyembryony prevails in *A. venusta* and is the normal condition in all firs that have thus far been examined. The product of each fertilized egg gives rise to a single embryo below the suspensor, and whether the four terminal embryonic cells contribute equally, as indicated in figures 17 and 18, or unequally, as indicated in figures 12 and 13, appears to make no distinguishable difference in later stages.

The suspensor *s*, composed of four cells, is remarkable in the amount of its elongation. Each cell elongates to about 60 times its original diameter before the terminal embryonic cells undergo their first division, and eventually becomes 150 to 200 times this length before the secondary suspensor begins to elongate, and before the primary suspensor cells collapse. Figure 16 has a suspensor in which each cell is fully 200 times as long as the width of these cells in figures 7 and 8. Figure 17 has suspensor cells that are not quite as long, but the ratio is fully 160 : 1. The latter has probably ceased elongation for the nuclei are no longer visible.

The secondary suspensor is formed by the elongation of cells (usually spoken of as embryonal tubes), from the distal end of the embryo, as shown in successive stages by figures 12, 13 (pl. 16) and 16–20 (pl. 17). As the enlarging embryo becomes wider, the number of elongating cells increases (figs. 13, 18), so that the secondary suspensor now becomes increasing'y more massive. The suspensor system may become greatly coiled and twisted. In dissections, some of these twists were removed, and those that are shown in the figures are not necessarily the ones that were most extreme before dissection. The newest additions of the secondary suspensor elongate most rapidly. These projecting newly-

Explanation of the Figures. Plate 16.

Plate 16. Stages in Embryogeny of Abies venusta. Figs. 7–8, earliest stages dissected show 12 cells of 16-celled proembryo still undivided. Fig. 9, lowest (embryonic) tier of cells has divided. Fig. 10, later stage after four embryonic cells have each become 4-celled, with details of embryo shown in surface view in 10a and in lower focus in 10b (×147). Fig. 11, later stage with 8 cells in each of the four embryonic cells. Fig. 12, formation of secondary suspensor by elongation of cells from distal end of embryo. Fig. 13, later stage of same, showing rosette embryos derived from rosette cells, and well developed secondary suspensor with the suspensor cells now irregularly interlocked. Figs. 14–15, rosette embryos from embryo systems of stage similar to Figs. 12–13. All figures, except 10a and 10b, × 60. *r* = tier of rosette cells; *s* = primary suspensor; *e* = tier of embryonic cells.

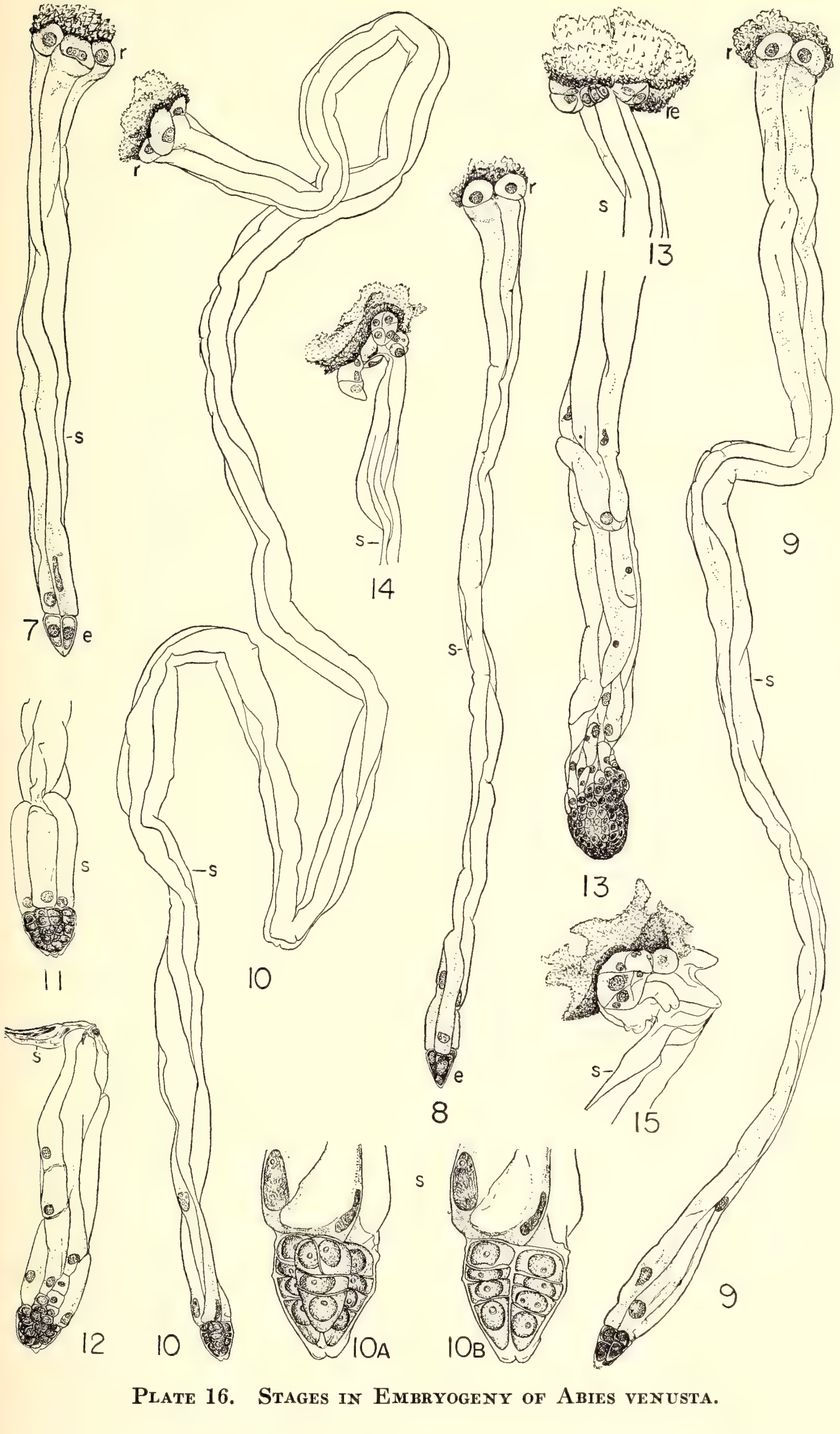

PLATE 16. STAGES IN EMBRYOGENY OF ABIES VENUSTA.

formed embryonal tubes usually ensnare any shorter embryos from another zygote that may be situated behind them and push the shorter rivals back toward the region of the archegonia.

Abies venusta usually forms rosette cells. A majority of these form rosette embryos, as may be seen in the upper part of figure 13 and in figures 14 and 15. These secondary embryos are formed only after considerable delay, during which the primary suspensor becomes fully elongated. In early stages shown by figures 7 to 10, and even in figure 16, the rosette cells usually remain undivided. In figure 17, each of the two rosette cells has divided once. Figures 14 and 15 were taken from embryos that had not only fully-elongated and collapsed primary suspensors, but the embryos had become massive and had developed secondary suspensors similar to those shown in figures 18 and 19. It was also observed that sometimes these rosette cells may fail to divide; the nuclei may disintegrate and the cells collapse without forming embryos.

The later stages of the successful embryos are shown in figures 19 and 20. *Abies venusta* agrees with other members of this family of conifers in that the primordium of the stem tip appears as a slight protuberance before the cotyledonary primordia are formed.

The embryo shown in figure 20 had 7 cotyledons surrounding and obscuring the primordium of the stem tip. The cotyledon number varied between 5 and 8. In a count of about 150 embryos, the mean number of cotyledons was 6.5.

The embryo of figure 20 has a conspicuous calyptroperiblem. This structure, which replaces the root cap in conifers, merges with the secondary suspensor and surrounds the plerome of the root tip. A ridge surrounding the embryo of figure 20 just below the middle marks the outer margin of the calyptroperiblem. In respect to this feature, the embryo of *A. venusta* resembles that of *Cedrus* (3) more than that of *Picea.*

Abies Pinsapo Boiss. Embryological material of the Spanish fir was obtained from reproductive specimens found on the Mills Estate at Millbrae and on the Flood estate near Menlo Park, both in California. Only the early stages in the embryogeny were satisfactory. In stages later than those shown in the accompanying figures (21–24), the embryos were all aborted and the entire gametophytes shriveled up so that no viable seeds were matured. In the early stages there was a remarkable similarity with the embryogeny of *A. venusta.*

Explanation of the Figures. Plate 17.

Plate 17. Later Stages in Embryogeny of Abies venusta. Figs. 16–17, embryo systems showing extreme length of suspensor in a stage subsequent to Fig. 10, $\times 60$. Fig. 18, embryo on well-developed secondary suspensor (stage following Figs. 11–13), $\times 60$. Fig. 19, stage showing primordium of stem tip, $\times 20$. Fig. 20, embryo after cotyledonary primordia have formed, $\times 20$. r = rosette cells; s = primary suspensor; e_1 = beginning of secondary suspensor.

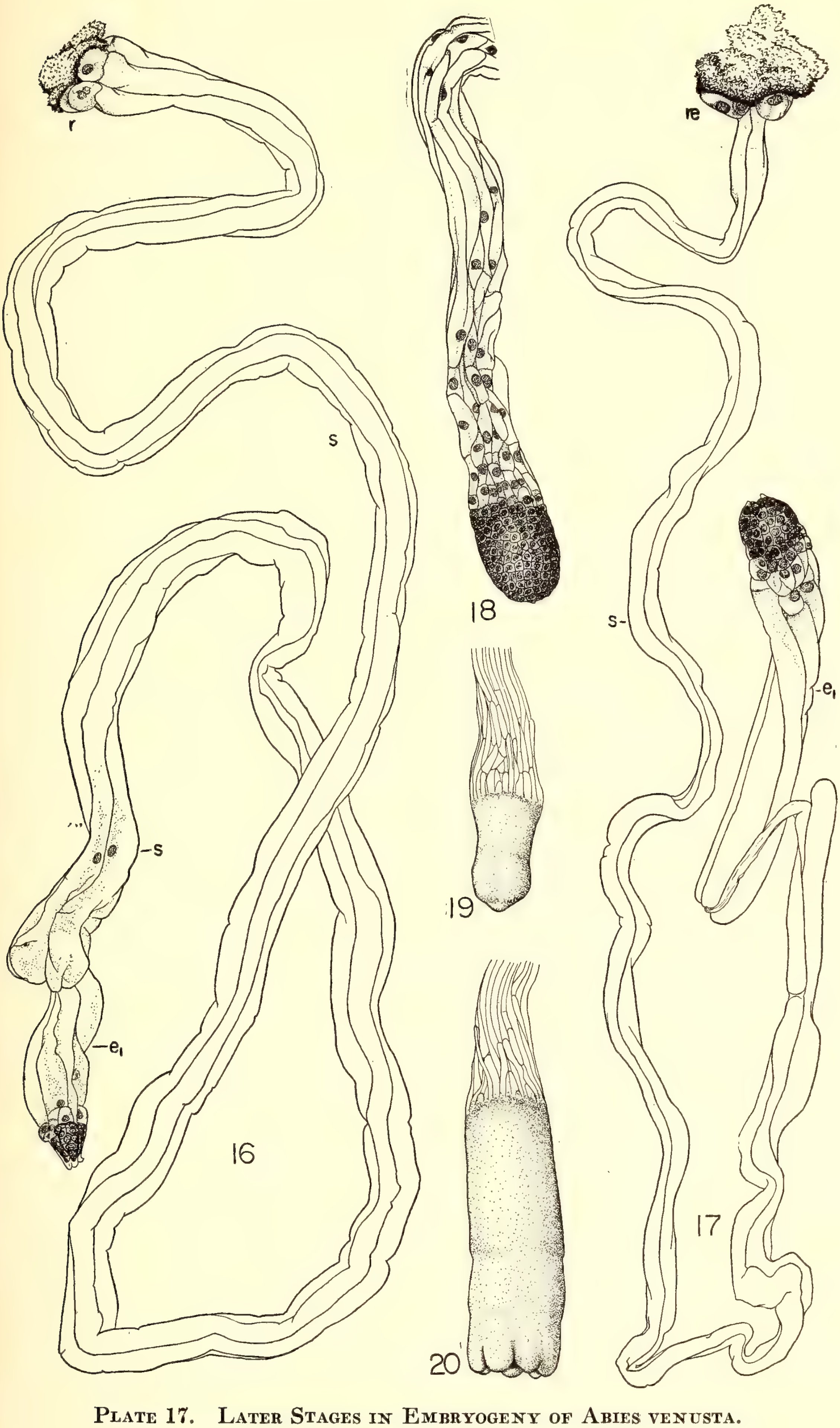

PLATE 17. LATER STAGES IN EMBRYOGENY OF ABIES VENUSTA.

Discussion

In the writer's earliest investigations on polyembryony (1), where the similarity in *Abies* and *Picea* with respect to simple polyembryony was stressed, the differences in the suspensor systems of these two genera was entirely overlooked. Unfortunately, these diagrams (copied by several authors) have been taken too literally. Much greater accuracy was achieved in a later publication (2), but in the second set of drawings, the rosette cells had usually collapsed in the embryos with long suspensors—those that were selected for the illustrations.

In re-examining these preparations, it is obvious that the single tier of primary suspensor cells of *Abies balsamea* collapses earlier and does not become as extreme in its elongation as the same structure in *A. venusta.* The difference between the spruce and fir is apparent in these old preparations and in the drawings made in 1930, which are fairly accurate, but the rosette cells and the older parts of the suspensor elements are so shriveled that they are very difficult to recognize.

Another feature which makes the rosettes and suspensor structures very difficult to study is not only the deposit shown above the rosette in nearly all of the figures, but a similar gummy or resinous deposit which surrounds the upper region of the suspensor system, omitted in all of the drawings.

There were several objectives that motivated this investigation. It was suspected that the embryogeny might offer features which would serve to separate *A. venusta* from the remaining firs and place it, either in one of the other genera or in a new genus. It was also desirable to discover the basis for a clearer definition of the differences between the genera *Picea* and *Abies,* both of which have simple polyembryony.

The taxonomic differences between *Abies venusta* and other firs are very marked. There are differences in the leaves, winter buds, bracts of the cone scale, and in the fact that the branches of this species are somewhat flexible and do not hold the cones erect as in other firs. The seed cones are inserted at nearly right angles on the twigs that bear them, are erect in early stages, but later their weight bends the slender twigs downward, so that many cones appear to be borne in horizontal positions, sometimes even drooping downward. The external differences may not be of great importance, but some of these characters such as the large peculiar winter buds and the very long, pointed leaves, so different from other firs, may have caused botanists to wonder whether this species may not represent something other than a true fir. In fact, several botanists, in discussing the unique external features in the Santa Lucia fir expressed the wish that the embryogeny be investigated in the hope that this might contribute new facts that might possibly prove to be decisive. *Abies Pinsapo* offered many external taxonomic features of contrast with *A. venusta.* How-

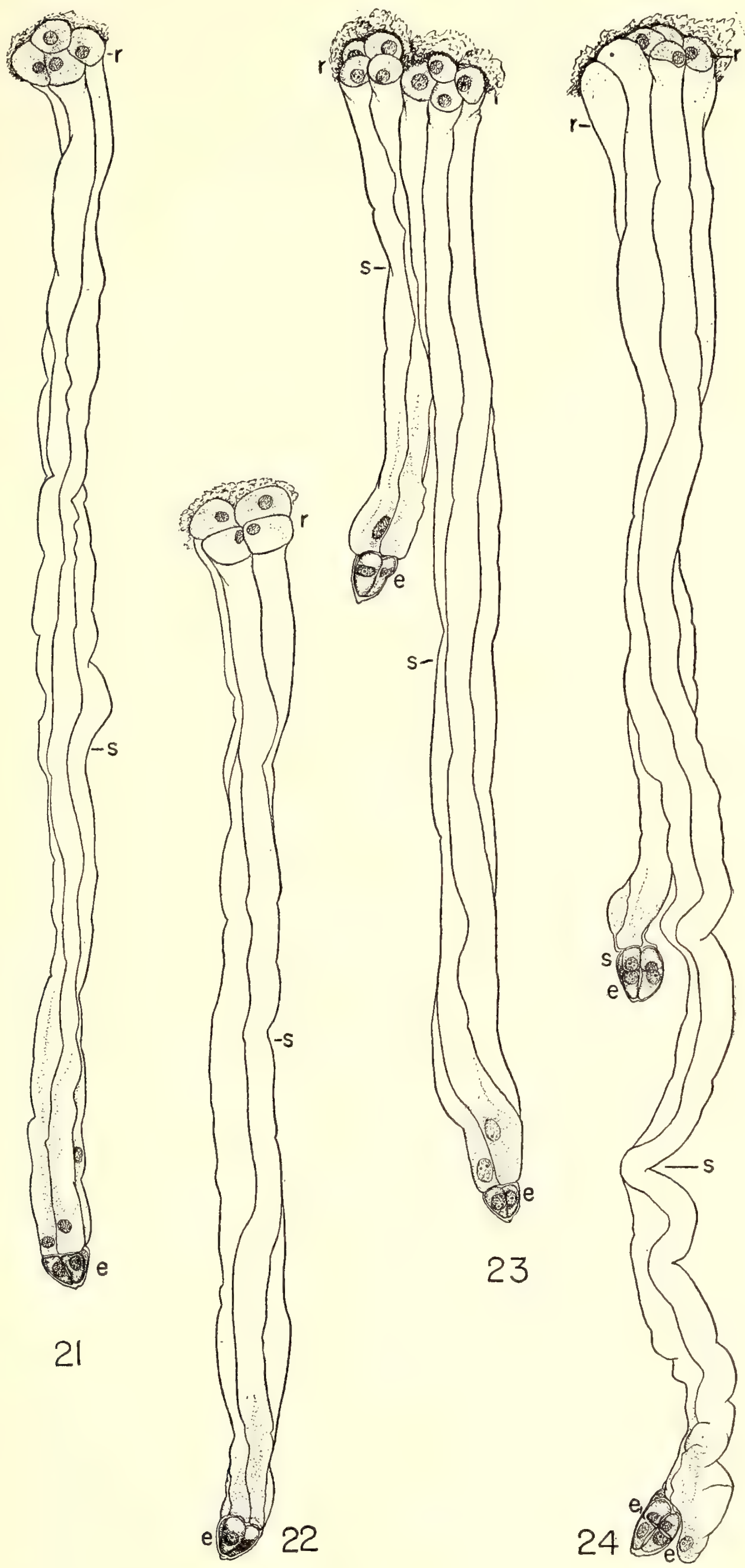

PLATE 18. SUCCESSIVE STAGES IN EMBRYOGENY OF ABIES PINSAPO. The paired embryo systems, Figs. 23–24, were dissected from the same ovules, ×60. *s* = primary suspensor; *e* = tier of embryonic cells.

ever, the embryogenies of these two species are in close agreement in the early stages that were observed.

Picea and *Abies* have a similar type of proembryo and both have simple polyembryony. Even though the proembryo of *Abies* has not been fully investigated, the three tiers of cells that remain are still undivided in the earliest stage shown in figure 7. The two genera differ, however, in the manner in which the suspensor system develops. In *Picea*, the primary suspensor tier (*s*) is followed by a succession of three or four similar additions, e_1, e_2, e_3, and e_4 before the secondary suspensor becomes irregular and may consist of many cells; in *Abies* a very long primary suspensor is formed which is directly succeeded by a more irregular many-celled secondary suspensor.

In *Picea*, rosette cells are formed but they usually abort and have not been observed to develop into embryos. In *Abies balsamea* and *A. Pinsapo*, these rosette cells usually fail to develop as in *Picea*, but in *A. venusta* a considerable number of instances were observed in which rosette cells developed into very small embryos.

Abies venusta agrees on the whole with the embryogeny of other species in this genus. It differs not only from *Picea* but also from *Pseudotsuga* (1, 2), in which no rosette cells are formed. *Abies venusta* differs from *Pinus*, *Cedrus* and *Tsuga*, all of which have cleavage polyembryony. There is no embryological feature in *A. venusta* which would tend to segregate it from the genus *Abies* save the rosette embryos which develop in a little more than half of the embryos. Other embryological characters that are distinctive in this species are quantitative in nature. The embryology of *A. venusta*, therefore, offers little in support of the idea that this species should belong to another genus. It definitely does not belong to any of the other genera now recognized and does not show embryological features which are sufficiently unique to suggest its segregation into a new genus.

Summary

1. The early embryogeny of *Picea Smithiana* is described with special reference to the development of the suspensor system.

2. The embryogeny of *Abies venusta* is described and compared with other firs, including *A. Pinsapo*, and with *Picea*.

3. Both genera begin their development with the same type of proembryo. In *Picea* the embryonic cells divide early and form three or four additional tiers of cells that elongate successively in adding relatively short tiers of elongated sections to the suspensor system. In *Abies* the embryonic cells do not divide until the suspensor tier has become well elongated. The suspensor cells elongate as a single tier, eventually becoming as long as the 3 to 4 tiers of additions in *Picea*, or even longer.

4. Rosette cells are formed in both genera. In *Picea* and some species of *Abies* the rosette cells do not divide to form em-

bryos; in *A. venusta* the rosette cells may form embryos after the suspensor tier has become fully elongated.

5. On the whole, the embryogeny of *Abies venusta* agrees closely with other firs. It does not belong in one of the other genera of Pinaceae and there seems to be little in the embryogeny which would suggest the segregation of *A. venusta* into a distinct genus.

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University of Illinois, Urbana,
July, 1941.

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ANATOMY AND ECOLOGY OF AMMOPHILA ARENARIA LINK

EDITH A. PURER

During a period of three years, studies were made upon sand dune plants along the Pacific coast from Oregon to Baja California. Environmental factors were measured and a study of the anatomy of twelve species was undertaken. In the subsequent publication (Purer, Studies of Certain Coastal Sand Dune Plants of Southern California, Ecol. Monog. 6: 1–88, 1936) the genus *Ammophila* was omitted since it was not abundant in the particular areas where the instrumental work was carried on.

Although it is not a native species, *Ammophila arenaria* Link has been successfully planted as a sand binder in a number of areas and is fairly well distributed along the Pacific coast. Specimens were examined at the herbaria in the following institutions, Stanford University (D); University of California (UC); and the University of Southern California (USC): Linnton, Oregon, September, 1927, *Thompson 3881* (D); Eureka Peninsula, Humboldt County, June, 1899, *Dudley* (D); Point Arena, Mendocino County, August, 1899, *Davy and Blasdale 6046* (UC); one-half mile south of Lake Merced, San Francisco County, May, 1901, *Dudley* (D); Jazos Creek, San Mateo County, March, 1922, *Bacigalupi* (D);

Oceano, San Luis Obispo County, October, 1930, *de Forest* (USC); Hueneme, Ventura County, August, 1931, *Purer 2213;* strand at Spanish Bight, San Diego County, October, 1931, *Purer 2311.*

Ammophila arenaria thrives in open places where there is little or no vegetation, where the wind is severe, the insolation great, and the soil unstable. As a rule this grass, commonly known as sand reed, grows alone on the dunes, although occasionally plants such as *Franseria bipinnatifida* may establish themselves on sand held by *Ammophila.* Concerning the stabilization of moving dune areas, A. S. Hitchcock (Controlling Sand Dunes in the United States and Europe, Nat. Geog. Mag. 15: 46, 1904) states: "Many plants have been tried, but the most satisfactory is beach grass (*Ammophila arenaria* Link). This grass grows naturally upon the sand dunes of the North Atlantic coast of Europe as far south as Morocco, and of America as far south as North Carolina, and also along our Great Lakes. This is the grass which was used in reclaiming land which is now Golden Gate Park in San Francisco." The highway department of Oregon has also planted this species as a sand binder on dune areas of the coast.

The sand reed grows in large clumps to a height of two to three feet, the stems and the roots being produced at the nodes of elongated rhizomes. From each node of the rhizomes five or six roots, about twenty-five centimeters long and usually bearing many secondary roots two to three centimeters in length, are produced. The plant withstands partial covering by sand through the production of adventitious roots from the buried portions of its erect stems. The entire root system is smaller in proportion to the aerial parts than in other principal sand dune plants. The leaf blades which are long and gradually narrowed to a point, bend in all planes without breaking. The blades are mostly vertically placed, receiving the minimum amount of light; only old leaves are bent at an angle. Since the plant grows in tufts its leaf blades shade each other somewhat. In San Luis Obispo County the young leaves were found tightly rolled and the old leaves partially unrolled. Farther south, where the habitat is even more xeric, the leaves were always found tightly rolled; in northern California and Oregon the leaves were habitually partially unrolled. According to E. Pee-Laby (Etude anatomique de la feuille des graminées de la France. Ann. Sci. Nat. Bot. 8: 227–346, 1898) such variation is due to the relative dryness of the habitat.

Explanation of the Figures. Plate 19.

Plate 19. Ammophila Arenaria. *A,* stem, transverse section; *B,* vascular bundle, transverse section; *C,* folded blade, diagrammatic transverse section; *D,* blade, transverse section; *E,* infolded adaxial epidermis of blade showing motor cells; *F,* epidermal cells and stomata on adaxial surface of blade; *G,* epidermal layer of blade showing stoma, transverse section; *H,* sheath, transverse section; *I,* epidermal layer of sheath showing stoma, transverse section; *J,* root, transverse section.

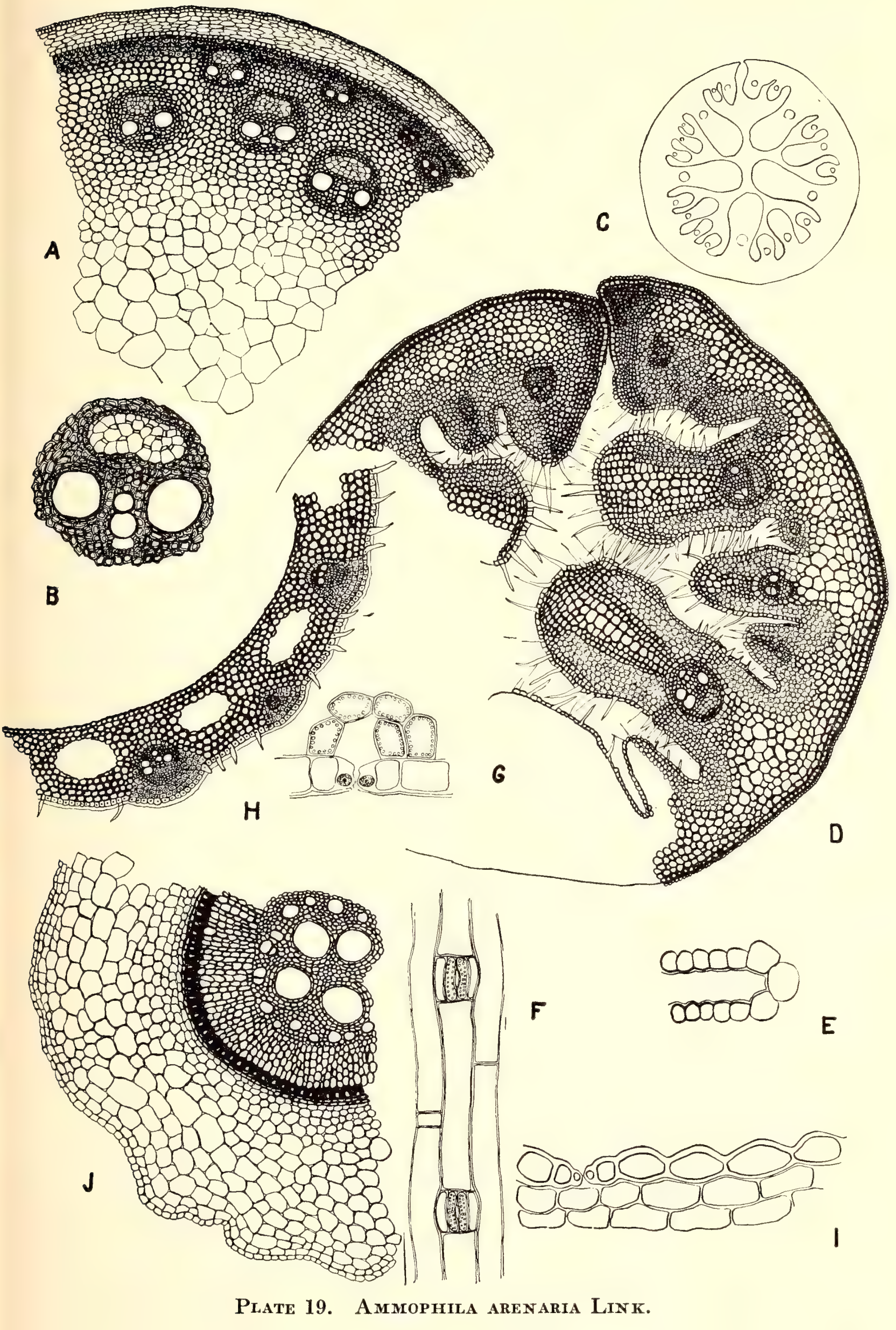

Plate 19. Ammophila arenaria Link.

The roots (pl. 19, fig. J) are short and fibrous, and when pulled from the soil easily lose their outer cortical layer. The epidermis is composed of small compactly-placed cells; inside of this is the cortex, composed of soft, closely placed parenchyma cells, which makes up about two-thirds of the root in cross-section. The endodermis is composed of very heavy-walled cells, the inner wall being especially thick while the pericycle is inconspicuous. The stele contains a few tracheae surrounded by sclerenchyma. Phloem is inconspicuous.

The stem (pl. 19, figs. A, B) is of simple monocotyledonous type, compact, with few intercellular spaces, the small epidermal cells having all their walls of about equal thickness and bearing a thin layer of cuticle. Within this tissue are about five or six rows of cortical parenchyma cells and on the inner side of these a definite ring of sclerenchyma. The scattered vascular bundles are disposed in a relatively narrow zone occupying about two-fifths of the radius, the outer bundles being embedded in the ring of sclerenchyma. The central pith is definite and conspicuous, composed of large cells occupying about three-fifths of the diameter of the young stem; old stems are usually hollow.

The outside epidermis of the sheath (pl. 19, figs. H, I) is covered with thick cuticle, and bears at frequent intervals, short, unicellular, unbranched, pointed trichomes. There is a single row of closed vascular bundles with conspicuous sheaths. Sclerenchyma surrounds these, and expands to a broad, wedge-shaped mass, causing a slight protrusion of the epidermis. In the tissue between the bundles are large lacunae running vertically through the sheath. On the inner surface in parallel rows stomata occasionally occur.

The blade and sheath portions of the leaf differ considerably in structure. The cylindrically rolled blade (pl. 19, figs. C, D) of the southern California plants is covered on the abaxial surface by a firm epidermis of small cells averaging 0.017 millimeters in their radial diameter. These bear a cuticle about 0.008 millimeters in thickness, or more than 47 per cent of the radial diameter of these cells. The outer surface of the epidermis is regularly undulate, which permits the blade to unroll without splitting the cuticle. There are no stomata in this surface. Below the epidermis are several rows of large sclerenchyma cells with moderately thick walls.

The adaxial surface of the blade, the inner face of the rolled blade, is ridged and grooved. The ridges, alternately large and small, are approximately 0.55 millimeters and 0.25 millimeters in height. The epidermis here averages 0.012 millimeters in thickness, and bears abundant unicellular, unbranched, conical trichomes with thick walls, varying in length from four to ten times the diameter of the epidermis; there is a cuticle about 0.002 millimeters in thickness, or about 17 per cent of the radial diameter

of these cells. The stomata (pl. 19, figs. F, G) which are confined to the sinuses, occur in parallel rows and number about twelve per square millimeter; the stomatal pore is about 0.0014 millimeters in its long diameter, with the guard cells and the subsidiary cells measuring about 0.040 by 0.035 millimeters. The central portion of each ridge contains sclerenchyma, with a single closed fibro-vascular bundle near the base of the ridge. Surrounding the grooves and extending up the sides of the ridges almost to their tops is a narrow band of chlorenchyma, which consists of small, more or less isodiametric, parenchyma cells containing numerous chloroplasts. The top of each ridge is completely filled with sclerenchyma to the point where the chlorenchyma begins. Groups of motor cells (pl. 19, fig. E) are found at the bottom of each of the grooves; the intercellular spaces are small and few. The ridged and grooved surface of the involute blade results in a withdrawal of the chlorenchyma from the light. Transpiration in the leaf is checked by inrolling, by the heavy cutinization of the abaxial surface, and by the infrequent stomata which occur only in the grooves of the inrolled epidermis where they are overlapped by the trichomes.

San Diego, California,
February 4, 1941.

AN UNDESCRIBED SPECIES OF CEANOTHUS FROM CALIFORNIA

Howard E. McMinn

Ceanothus Masonii sp. nov. *C. rigidus* variation 1 McMinn, Contrib. Dudley Herb. 1: 145. 1930, in part. *C. gloriosus* var. *exaltatus* J. T. Howell, Leafl. West. Bot. 2: 44. 1937, in part. Bolinas Ceanothus.

Frutex erectus vel erecto-patens, 6–18 dm. altus, ramis crassis arcuato-divaricatis, ramulis rigidis atro-fuscis vel purpureis, tomentulosis demum glabrescentibus; folia opposita persistentia, laminis late ellipticis vel fere orbicularibus, 6–19 mm. longis, 5–12 mm. latis, basi rotundis apice rotundis truncatisve, aliquando emarginatis, supra atroviridibus nitidis glabris, subtus albidis sub microscopio inter venas canescentibus, crebre dentatis dentibus brevibus aut rare leviter sinuato-dentatis ad basim versus integris; stipulae prominentes persistentes, 1.6–5 mm. longae; gemmae squamae fuscae glabrae vel leviter tomentulosae; inflorescentia subumbellata conglomerata, plerumque foliis binatis parvis subtentia, ramos breves (6–19 mm. longis) terminantia; flores atrocyanei vel purpurei; fructus globosus, tricornutus, 5 mm. diametro, cornibus brevibus apicalibus subapicalibusve, sine crestis intermediis instructus.

Erect or erect-spreading shrub, 6–18 dm. tall, with stout rather stiff divaricate branches and rigid dark brown or purplish tomen-

tulose branchlets, becoming glabrous in age; leaves opposite, evergreen; the blades broadly elliptical to oval or nearly orbicular, 6–19 mm. long, 5–12 mm. broad, rounded or sometimes cuneate at base, obtuse, rounded or truncate at apex, sometimes emarginate, dark green, glabrous and glossy above, grayish white and microscopically canescent between veins beneath, margins with numerous short teeth or rarely slightly sinuate-dentate except near base; stipules prominent, persistent, 1.6–5 mm. long; bud scales brown, glabrous, or slightly tomentulose; flowers dark blue to purple, in many-flowered umbel-like clusters usually subtended by a pair of small leaves terminating short lateral branchlets 6–19 mm. long; fruit globose, about 5 mm. in diameter, with 3 short apical or subapical horns, without intermediate crests. Flowering period, March, April.

Type. Along trail on east end of Bolinas Ridge, Marin County, California, April 23, 1933, *McMinn 3044*, deposited in the University of California Herbarium, Berkeley, no. 657,550. Other representative collections: *McMinn 906, 5416, 5417;* transplant series, *McMinn 1574R, 1574O, 1574Q; Eastwood & Howell 3838.*

Bolinas Ceanothus occurs on Bolinas Ridge, Marin County, California. It is very closely related to *Ceanothus gloriosus* var. *exaltatus* J. T. Howell. These two entities belong to the *C. gloriosus-C. ramulosus-C. purpureus-C. divergens-C. confusus* complex which occurs in the North Coast Ranges of California, in Marin, Sonoma, Napa and Mendocino counties. My first acquaintance with the entity was in February, 1923, when I collected seven small plants (tentatively referring them to *C. rigidus* var. *grandifolius* Torr.) and transplanted them to the trial gardens at Mills College. On March 30, 1923, I revisited the area on Bolinas Ridge in company with Herbert L. Mason. We found vigorous mature plants associated with *Ceanothus foliosus, Arctostaphylos sensitiva, A. virgata, Quercus Wislizenii* var. *frutescens, Sphacele calycina* and *Adenostoma fasciculatum,* in an area of about two miles along the ridge. These plants occupied the drier habitats of the ridge crest.

In the late summer of 1924, a fire burned over Bolinas Ridge and destroyed most of the plants. On December 20, 1925, I again collected along the ridge. Not a single old plant of Bolinas Ceanothus was found; all had been destroyed by the fire of 1924. However, seedlings were abundant along the trail throughout the area. Twenty-three seedlings, from 4 to 12 inches tall were taken up and transplanted to the trial gardens at Mills College. At this writing, just sixteen years later, all but one (1574R) of the transplants have died. This lone survivor is about 6 feet tall and has a spread of 18 by 18 feet. The trunk at the ground is about 8 inches in diameter.

In October, 1941, Dr. Mason and I studied the species of *Ceanothus* occurring on the south slope of Mount Tamalpais and

along Bolinas Ridge. *Ceanothus Masonii* was the most abundant species along Bolinas Ridge in the area which had been burned in 1924. I do not know how many times the ridge has been burned over subsequently; however, since some of the plants appeared to be at least six or seven years old, no destructive fires have occurred since 1935. Many seedlings and young plants abound in and along the ridge trail which has been cleared from time to time for use as a fire road. In addition to many plants of typical Bolinas Ceanothus, a few plants with leaves simulating those of *C. purpureus* Jepson, and a few with leaves intermediate between the two, were observed. A few plants with the large leaves and habit of growth of *C. gloriosus* var. *exaltatus* and others with smaller leaves intermediate between those of *C. ramulosus* (Greene) McMinn and *C. purpureus* were found growing along the ridge. These facts supported by additional observations made upon certain *Ceanothus* entities occurring in the North Coast Ranges, lead to the conclusion that Bolinas Ceanothus is a member of a large complex, which may consist of several species occupying different geographical and probably ecological niches.

Mills College, California,
November 27, 1941.

NOTES AND NEWS

Range Extensions in Species of Western North America. New localities have been reported recently for the following species:

Boykinia Jamesii Engelm. var. heucheriformis (Rydb.) Rosendahl. Growing in crevices of limestone cliffs, altitude 8800 feet, Canadian zone, above White Pine Lake, northeast slopes of Mount Magog, Cache County, Utah, July 17, 1936, *Maguire 14046*. This species is known from Colorado, Idaho and Nevada, but heretofore has not been reported from Utah.

Saxifraga eriophora S. Watson. This rare plant, apparently known previously only from the type locality in the Santa Catalina Mountains, Arizona, has been collected as follows: common, moist ravine slopes along stream course in yellow pine and oak, altitude 8500 feet, Pine Crest, Pinaleno (Graham) Mountains, Graham County, Arizona, April 17, 1935, *B. & R. Maguire 10545;* altitude 8000 feet, May 26, 1936, *B. & R. Maguire 12012,* May 28, 1935, *B. & R. Maguire 12014*.—Bassett Maguire, Intermountain Herbarium, Utah State Agricultural College, Logan.

Eriodictyon capitatum Eastwood. Previously known only from Pine Canyon on Burton Mesa, five miles north of Lompoc, this species was discovered in a canyon on the James J. Hollister ranch, approximately five miles northeast of Point Conception, Santa Barbara County, California. Here, on a west-facing slope, elevation 900 feet, at the head of the west fork of Barranca

Honda, the shrub is associated with *Ceanothus cuneatus, C. papillosus, Phacelia ramosissima* var. *suffrutescens, Quercus agrifolia* and *Salvia mellifera* (July 20, 1941, *Tucker 342,* University of California Herbarium).—John M. Tucker, Department of Botany, University of California, Berkeley.

Ornamental Shrubs and Woody Vines of the Pacific Coast. By Evelyn Graham and Howard E. McMinn; published October, 1941, under the auspices of Mills College, California, by the Gillick Press, Berkeley, California; price $3.00. In this volume of 259 pages the authors have presented the first general treatise on the shrubs and vines cultivated in California. The descriptions are brief and for the most part entirely non-technical, although as a convenience a comprehensive glossary of botanical terms is included. An introductory chapter presents a concise account of flowering plant organs and their functions for those who may not have had previous training in botany. Practical keys are supplied for all genera and species treated. The book is well illustrated with twenty-two plates from natural color photographs, also with 144 figures consisting of both photographs and line drawings. With this volume in hand any interested person should be able to name most of the commonly cultivated ornamental shrubs and vines of the state.—E. Crum.

Weeds of California. By W. W. Robbins, Margaret K. Bellue, and Walter S. Ball; published, 1941, by the State Department of Agriculture, Sacramento, California; price $2.00. This useful work, succeeding Smiley's "Weeds of California," long since out of print, is the result of years of cooperation in research and field practice between the Division of Botany, College of Agriculture, University of California, Davis, and the Division of Plant Industry, State Department of Agriculture. Descriptions, origins and distributions of 693 species of weedy plants are included; in addition the control of weeds is discussed and weeds of special crops and soils are listed. Technical terms in keys and descriptions are avoided as much as possible. The volume is well illustrated with line drawings, photographs and 24 colored plates from the work of Lena Scott Harris. Sixteen maps showing the approximate distribution of certain important species are included.—A. Carter.

Plant Hunters in the Andes. By T. Harper Goodspeed; published October, 1941, by Farrar and Rinehart, Inc.; price $5.00. In this attractive volume are recounted the adventures of the members of the recent University of California Botanical Garden Expeditions to South America, especially to the Andean regions of Peru and Chile. Dr. Goodspeed, Director of the Botanical Garden and leader of the expeditions, has presented in a very readable manner material of both botanical and general interest. The book consists of 429 pages and is profusely illustrated with

photographs not only of the plant life and topography of the regions visited but also of certain social aspects of the South American scene.—E. Crum.

Desert Wild Flowers. By E. C. Jaeger; second edition, published October, 1941, Stanford University Press; price $3.50. In this second edition a sixteen page popular key has been added that seems adequate when used in combination with the excellent drawings. Necessary corrections in the text have been made. The completeness of this attractive guide to the plants commends it to all who enjoy the deserts of California and their adjacent borders.—David D. Keck.

The fourteenth annual meeting of the Western Society of Naturalists was held at Stanford University, December 29 to 31, 1941. An important feature of the program was a symposium dealing with the genetic basis of evolution. The following papers were presented: "Genetic Evolutionary Processes in Crepis," Professor E. B. Babcock, University of California; "The Pattern of Relationships Revealed by Morphologic, Ecologic and Cytogenetic Evidence," Dr. Jens Clausen, Carnegie Institution of Washington Laboratory, Stanford University; "The Sterility Barrier," Dr. R. B. Goldschmidt, University of California; "Where Does Adaptation Come In?" Dr. F. B. Sumner, Scripps Institution of Oceanography, University of California. Dr. Herbert L. Mason, University of California, presided and led the subsequent discussion.

Mr. J. Francis Macbride and Dr. Francis Drouet, members of the Herbarium staff, Field Museum, Chicago, spent some time in California this fall. During part of October they collected algae, mainly in the desert regions of southern California. Mr. Macbride, however, spent nearly two months in Berkeley where he was studying the South American collections in the University of California Herbarium in connection with his work on the "Flora of Peru."

PROCEEDINGS OF THE CALIFORNIA BOTANICAL SOCIETY

May 15, 1941. Meeting, 2093 Life Sciences Building, University of California, Berkeley, at 7:45 P. M. Dr. G. Ledyard Stebbins, Jr., Chairman of the Program Committee, occupied the chair. Dr. Norman H. Boke, of the University of California Botanical Garden, Berkeley, gave a lecture on "The Structure of the Cactus Plant." The talk was illustrated by prepared sections of cactus tissue, shown through a microprojector, and by a collection of representative cactaceous genera loaned by Mr. Jack Whitehead.

September 18, 1941. Meeting, 2093 Life Sciences Building, University of California, Berkeley, at 7:45 P. M. The President, Professor E. B. Babcock, occupied the chair. Dr. Ralph Emerson, Instructor in Botany, University of California, Berkeley, presented an illustrated lecture on, "An Interpretation of the 'New Systematics' in the Lower Fungi."

October 16, 1941. Meeting, 2503 Life Sciences Building, University of California, Berkeley, at 7:45 P. M. The President, Professor E. B. Babcock, occupied the chair. The President appointed a Membership Committee, consisting of Dr. Alan A. Beetle, Dr. Ralph Emerson and Dr. Reed C. Rollins. Mr. E. Yale Dawson, Teaching Assistant in Botany, University of California, Berkeley, presented an illustrated lecture on, "Exploring for Algae in the Gulf of California."

November 27, 1941. Meeting, 2093 Life Sciences Building, University of California, Berkeley, at 7:45 P. M. The President, Professor E. B. Babcock, occupied the chair. Professor H. E. McMinn, Chairman of the Nominating Committee, submitted the names of the following candidates: President, Dr. Alva R. Davis; First Vice-President, Dr. Palmer Stockwell; Second Vice-President, Dr. Reed C. Rollins; Secretary, Dr. Mildred E. Mathias; Treasurer, Dr. William M. Hiesey. A motion, made and seconded, to accept the report of the nominating committee, was passed unanimously. There were no nominations from the floor. Dr. Howard S. Reed, Professor of Plant Physiology, University of California, Berkeley, presented an illustrated lecture on, "The Migrations of the Citrus Fruits."

Following are the names of persons who have affiliated with the California Botanical Society since the publication of the list of members, April, 1940: Dr. Gordon D. Alcorn; Dr. Vada H. Allen; Mr. William H. Baker; Dr. Fred A. Barkley; Dr. J. T. Barrett; Mr. Kay H. Beach; Mrs. Margaret K. Bellue; Mr. W. Sidney Boyle; Dr. Muriel Bradley; Mr. Conrad M. Brown; Mr. Alfred J. Burrows; Dr. Marion S. Cave; Dr. Walter P. Cottam; Dr. Alden S. Crafts; Dr. Robert A. Darrow; Miss Bernice E. Doyel; Mr. M. B. Dunkle; Mr. Erl H. Ellis; Dr. Ralph Emerson; Dr. Katherine Esau; Professor A. O. Garrett; Mr. M. French Gilman; Dr. T. Harper Goodspeed; Mr. Arthur H. Holmgren; Mr. J. Wendell Howe; Mrs. Lilla Leach; Mr. Harlan Lewis; Dr. W. H. Long; Mr. Elmer Lorenz; Mr. Gregory S. Lyon; Miss Lois McCasky; Mr. James B. McNair; Mr. Oliver V. Matthews; Mr. Roy D. Metcalf; Mr. Reid Moran; Mr. Thomas Morley; Dr. W. C. Muenscher; Mr. David G. Nichols; Mrs. Doris K. Niles; Mr. M. A. Nobs; Mr. Donald Culross Peattie; Mr. Frank W. Peirson; Mr. R. L. Piemeisel; Dr. Ethel I. Sanborn; Dr. Michael Shapovalov; Mr. Edward Stuhl; Miss Helen Talbot; Mr. John M. Tucker.—Lincoln Constance, Secretary.

VOLUME VI NUMBER 6

MADROÑO

A WEST AMERICAN JOURNAL OF BOTANY

Contents

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DEVELOPMENT OF THE FEMALE GAMETOPHYTE IN ERYTHRONIUM HELENAE AND ERYTHRONIUM TUOLUMNENSE

Marion S. Cave

The type of development of the female gametophyte which Bambacioni (2) described for *Fritillaria* in 1928 has been shown to occur in the first five of the ten genera listed by Hutchinson (10) in the tribe Tulipeae: *Erythronium, Fritillaria, Tulipa, Gagea, Lilium, Lloydia, Nomocharis, Notholirion, Giraldiella,* and *Calochortus.* In this type of development, of the four nuclei resulting from the two divisions of meiosis, three migrate to the chalazal end of the embryo sac while the fourth remains at the micropylar end. At the following division the latter divides normally giving rise to two haploid nuclei. The chromosomes of the three dividing chalazal nuclei become aligned on one spindle, thus giving rise to two daughter nuclei, each of which has 3n chromosomes. This second group of four nuclei goes through the final division to produce an eight-nucleate gametophyte with four haploid nuclei at the micropylar end and four triploid at the chalazal. The primary endosperm nucleus is formed by fusion of a polar nucleus from each group and is thus 4n.

Representatives of the five genera in which the *Fritillaria* type of female gametophyte development is known are: *Fritillaria persica* (2); *Tulipa Gesneriana* (3), and a triploid form of the same (4); *Erythronium Dens-canis* (9), and *E. japonicum* (13); *Lilium Henryi* (6), *L. philippinense* (15), *L. tigrinum* (20), and *Cardiocrinum cordatum* Makino (= *Lilium cordifolium* Thunberg) (12); *Gagea minima* and *G. lutea* (11, 19), *G. ova, G. graminifolia* and *G. tenera* (14).

So far as the author knows no work has yet been published on *Lloydia, Giraldiella, Notholirion* and *Nomocharis. Calochortus* (5) is the only genus of the tribe thus far shown to have the "normal" type of macrosporogenesis and development of the female gametophyte.

In *Erythronium* both the *Fritillaria* and *Adoxa* types of development have been described. Hrubý (9) described the process in *Erythronium Dens-canis* with twelve pairs of chromosomes up to the stage where three nuclei are seen at the chalazal end and it may be assumed that this species would hold to the *Fritillaria* type. Oikawa (13) has followed the complete development in *Erythronium japonicum* (n = 12) and found it to be of the *Fritillaria* type. However, Cooper (7) has found the *Adoxa* type in a 22-paired *Erythronium albidum.* Schaffner (17) described gametophyte development for *Erythronium americanum* and *E. albidum* (both with twelve pairs of chromosomes). From his description and figures development seems to follow the *Adoxa* scheme, but

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since this work was done prior to 1928 there may be a possibility that Schaffner missed seeing the chalazal fusion as did all other workers before this time. Guerin (8) stated that the development in *Erythronium Dens-canis* is analagous to that which has been known "depuis longtemps chez *Lilium, Tulipa,* et *Fritillaria.*"

According to Applegate (1) there are three to four species of *Erythronium* in Eurasia, five in North America east of the Rockies, and fifteen west of the Rockies. Since those of eastern North America and Europe and Asia apparently show differences in the type of development of the female gametophyte, it was thought that study of this point in some of the western North American species would be of interest. Investigation of two Californian species, *Erythronium helenae* Applegate of section Concolorae and *E. tuolumnense* Applegate of section Pardalinae was therefore undertaken.

Materials. Ovaries of these two species of *Erythronium* were fixed in CRAF, dehydrated by normal butyl alcohol, and embedded in paraffin. Sections were cut at 10, 15, and 20 microns. Three stains were employed: Heidenhain's iron alum haematoxylin, Stockwell's modification of Fleming's triple stain, and the Feulgen stain, counterstained with fast green. Haematoxylin was perhaps the best for sections at 10 microns but the Feulgen and fast green was by far the best for thicker sections.

Development of the Female Gametophyte

The embryo sac mother cell (the archesporial cell) is located directly below a single layer of nucellus cells (pl. 20, figs. 1 and 2). The cytoplasm is finely vacuolate throughout with a somewhat denser layer around the spindle. At metaphase of the heterotypic division (pl. 20, fig. 3) it was impossible to determine the exact number of bivalents since all metaphase plates seen were in more than one section and some of the bivalents may have been cut. However, there seemed to be around twelve in *E. helenae.* No heterotypic mitoses were observed in *E. tuolumnense,* but somatic plates indicated no large number such as Cooper (7) found in *E. albidum.*

The two nuclei resulting from the heterotypic division lie at opposite ends of the embryo sac (pl. 21, fig. 4). There is no resting period at this time and the homeotypic division proceeds at once. The spindles of this division also are surrounded by a dense layer of cytoplasm (pl. 21, figs. 5 and 6). No vacuole is yet observable in the sac.

At the end of this division there are four haploid nuclei in the sac. In *Erythronium helenae,* but not in *E. tuolumnense,* faint lines which are apparently fibers are often seen connecting the nuclei. Text figure 1 which is a camera lucida drawing of figure 8 (pl. 22) shows that fibers connect the two central nuclei not only with each other but also with the nuclei at the micropylar and chalazal ends. Stenar's (18) figures 3b and 7c show connecting fibers in

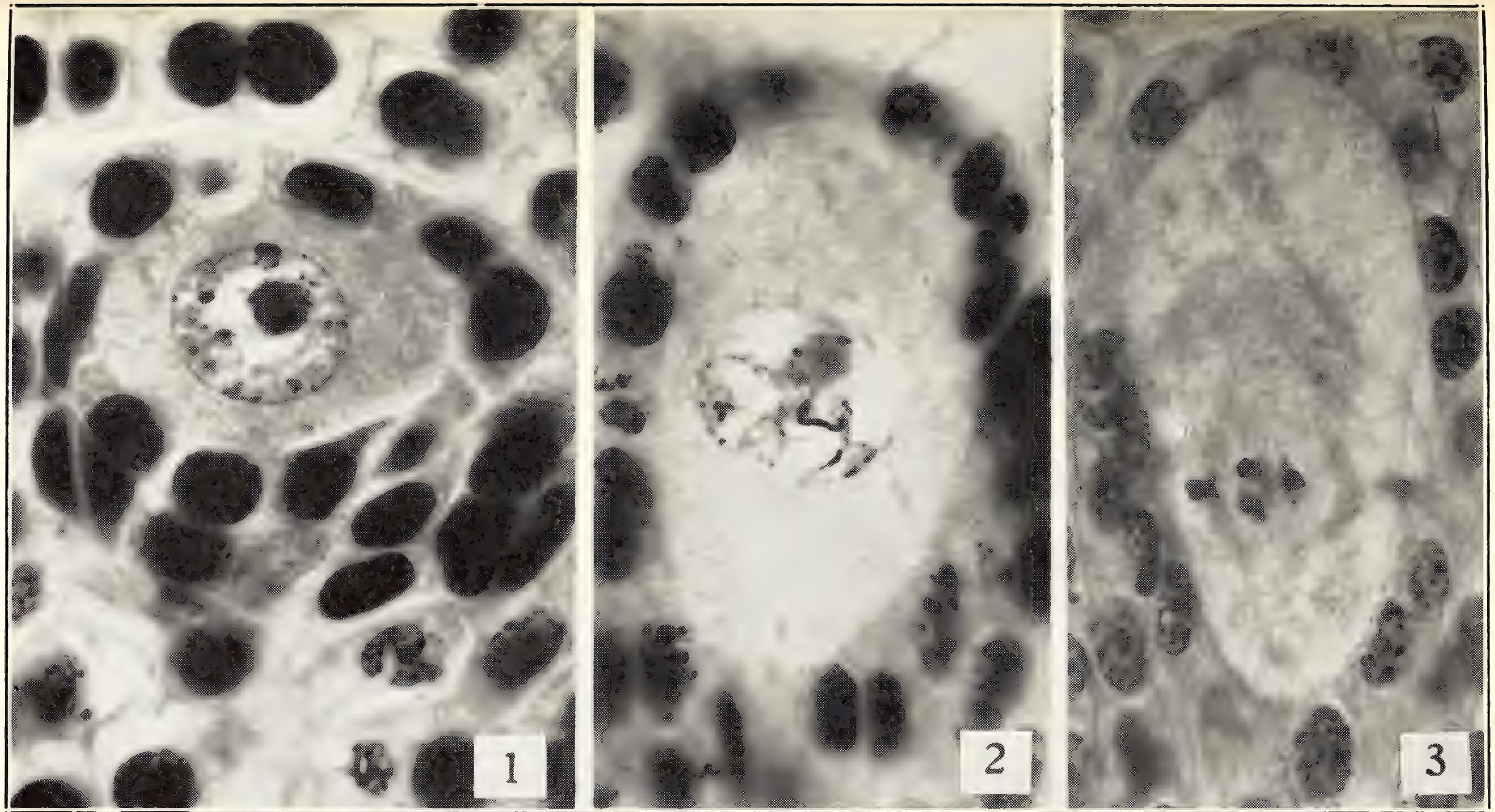

Plate 20. Development of female gametophyte in Erythronium. Fig. 1. Archesporial or embryo sac mother cell in *E. helenae*. Fig. 2. Prophase of heterotypic division in *E. tuolumnense*. Fig. 3. Metaphase of heterotypic division in *E. helenae*. All × 700.

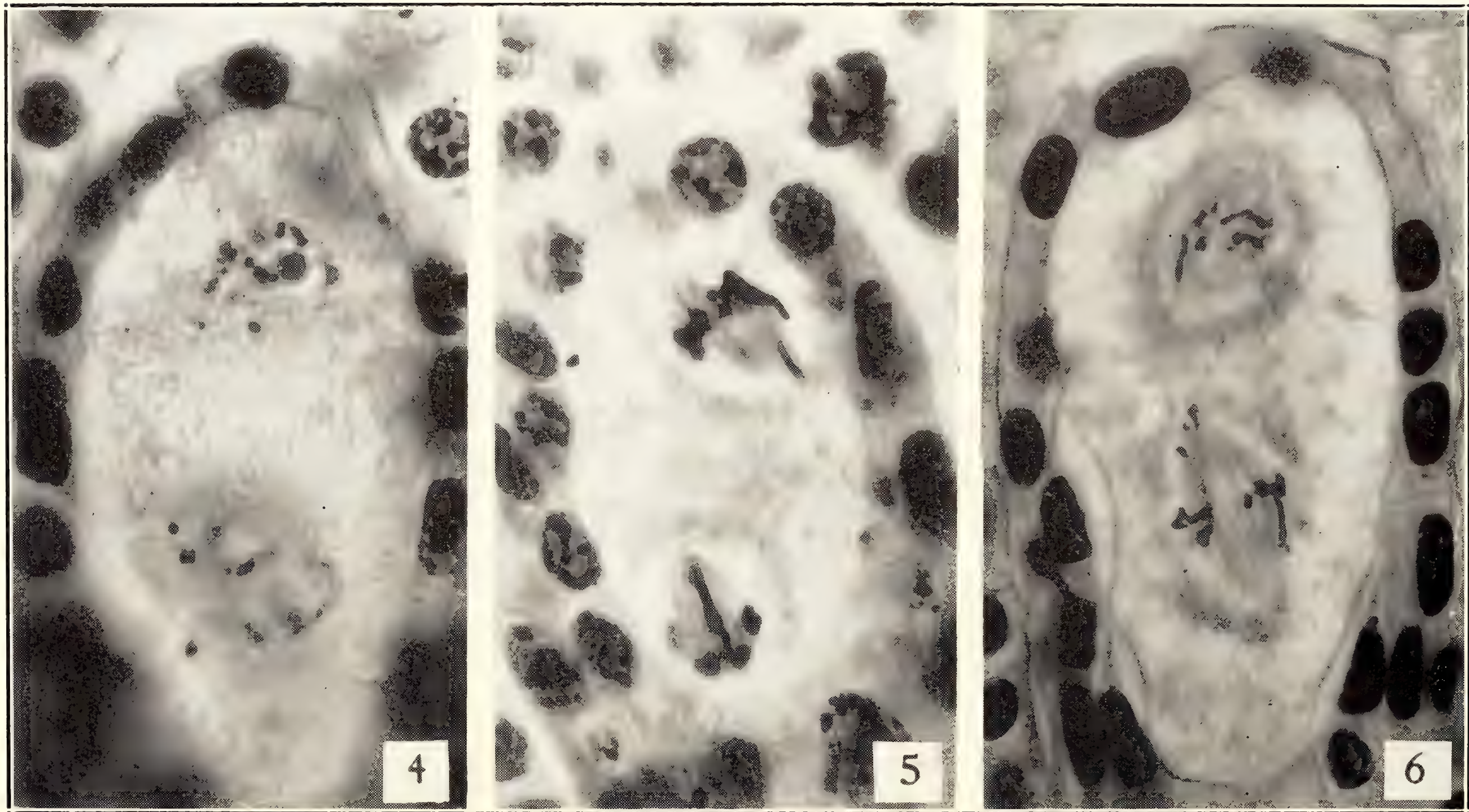

Plate 21. Development of female gametophyte in Erythronium. Fig. 4. Two nuclei resulting from heterotypic division in *E. helenae*. Fig. 5. Prophase of second division in *E. tuolumnense*. Fig. 6. Prophase of second division in *E. helenae*. Note dense cytoplasmic region around spindles. All $\times 700$.

Gagea lutea and *G. minima* in the same configuration. Figure 7 (pl. 22) shows three nuclei at the micropylar end connected by fibers and the lowest of these furthermore connected with the nucleus at the chalazal end (in the adjacent section). Bambacioni and Giombini's (3) figure 9 in *Tulipa Gesneriana* shows a similar arrangement of fibers. In Romanov's (14) photomicrographs of *Gagea graminifolia* in his figure 7c the three chalazal nuclei can be seen connected by faint fibers. Joshi (11) mentions secondary spindle fibers arising to connect the homeotypic spindles in *Gagea fascicularis*.

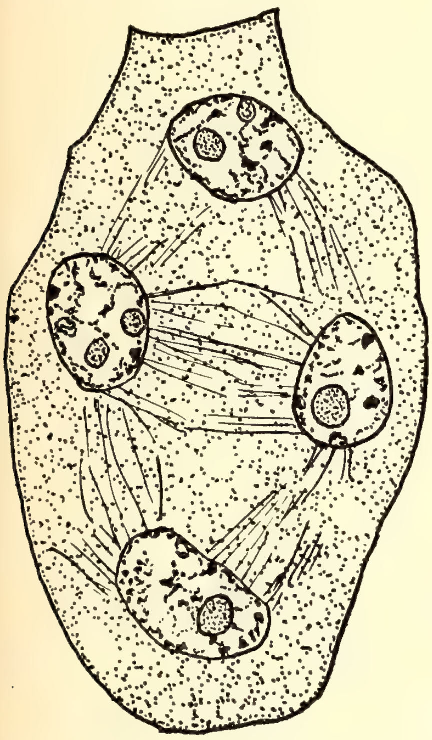

Fig. 1. Four haploid nuclei in *Erythronium helenae* all connected by fibers (camera lucida drawing of embryo sac shown in pl. 22, fig. 8).

Since these four haploid nuclei are the result of meiosis and therefore correspond to the four macrospores of a "normal" macrosporogenesis which are separated by cell walls, it may be that the fibers under discussion represent vestigial traces of cell wall initiation between the spores. If walls should form across all the fibers in figures 7 and 8 (pl. 22) each nucleus would then be separated frum every other as in spore formation. A somewhat similar condition exists in a young multicellular endosperm where fibers arise to connect all the nuclei, and walls separating them then appear across the fibers throughout the endosperm. However, no walls are produced between the haploid nuclei in the embryo sac and the fibers have completely disappeared by the beginning of third prophase.

In both species three of the four haploid nuclei migrate to the chalazal end of the sac. In *E. tuolumnense* a large vacuole separates the three chalazal nuclei from the micropylar and a smaller vacuole is found at the center of the three (pl. 22, fig. 9). In *E. helenae* no vacuole is present until the second four-nucleate stage (pl. 23, fig. 12 and pl. 24, fig. 14).

At prophase of the third division the three chalazal nuclei start to fuse (pl. 23, figs. 10 and 11). Often from telophase of the second division through metaphase and telophase of the third in *E. helenae* many small bodies in the cytoplasm which stain black with haematoxylin, but do not stain with the Feulgen technique, are seen (pl. 23, fig. 12). They are pictured by Schaffner (17) in *E. albidum* in his figure 59 although this is apparently only the telophase of the first division. Hrubý shows them at the telophase of the second division and suggests that they are leuco-

plasts since they stain faint blue with picroindigocarmine. The writer has seen them also at the third division in *Lilium longiflorum* and Sargant (16) shows them in *Lilium Martagon.* They were also noted by Stenar (18) in *Gagea lutea.*

In the third division it is apparent that there are many more chromosomes in the mitosis at the chalazal end than in that at the micropylar (pl. 23, fig. 12 and pl. 24, fig. 13). Figure 13 (pl. 24) is a polar view of the chalazal nucleus at anaphase of the third division. All the chromosomes are not in focus but many more than the haploid number seem to be present.

In both species the second four-nucleate stage is characterized by two large elongated nuclei at the chalazal end separated by a vacuole from the two more nearly spherical nuclei at the micropylar end (pl. 24, fig. 14). A fourth division occurs to give rise to an eight-nucleate female gametophyte (pl. 24, fig. 15). The inner chalazal nucleus divides into two nuclei by means of a more or less abortive mitosis (pl. 24, fig. 15). In flowers which had been open several days fusion of the polar nuclei had not yet taken place.

Summary

1. A study was made of the female gametophyte of two Californian species of *Erythronium, E. helenae* Applegate and *E. tuolumnense* Applegate, with a view to comparing their development with that found in eastern North American and Eurasian species.

2. Three of the four haploid nuclei resulting from meiosis migrate to the chalazal end of the embryo sac while the fourth goes to the micropylar end. In the following division the micropylar nucleus divides normally giving rise to two haploid nuclei, whereas the chromosomes of the three chalazal nuclei become aligned on one spindle and produce two 3n daughter nuclei. Each of the four nuclei now found in the embryo sac divides normally once again to give rise to an eight-nucleate gametophyte with three haploid nuclei at the micropylar end, three triploid at the chalazal, and one haploid and one triploid polar nucleus in the center.

3. In the two Californian species of *Erythronium* investigated development of the female gametophyte therefore follows the *Fritillaria* scheme as is true for the Eurasian species, while the *Adoxa* scheme occurs in *Erythronium albidum* from eastern North America.

Department of Botany,
University of California, Berkeley,
September 5, 1941.

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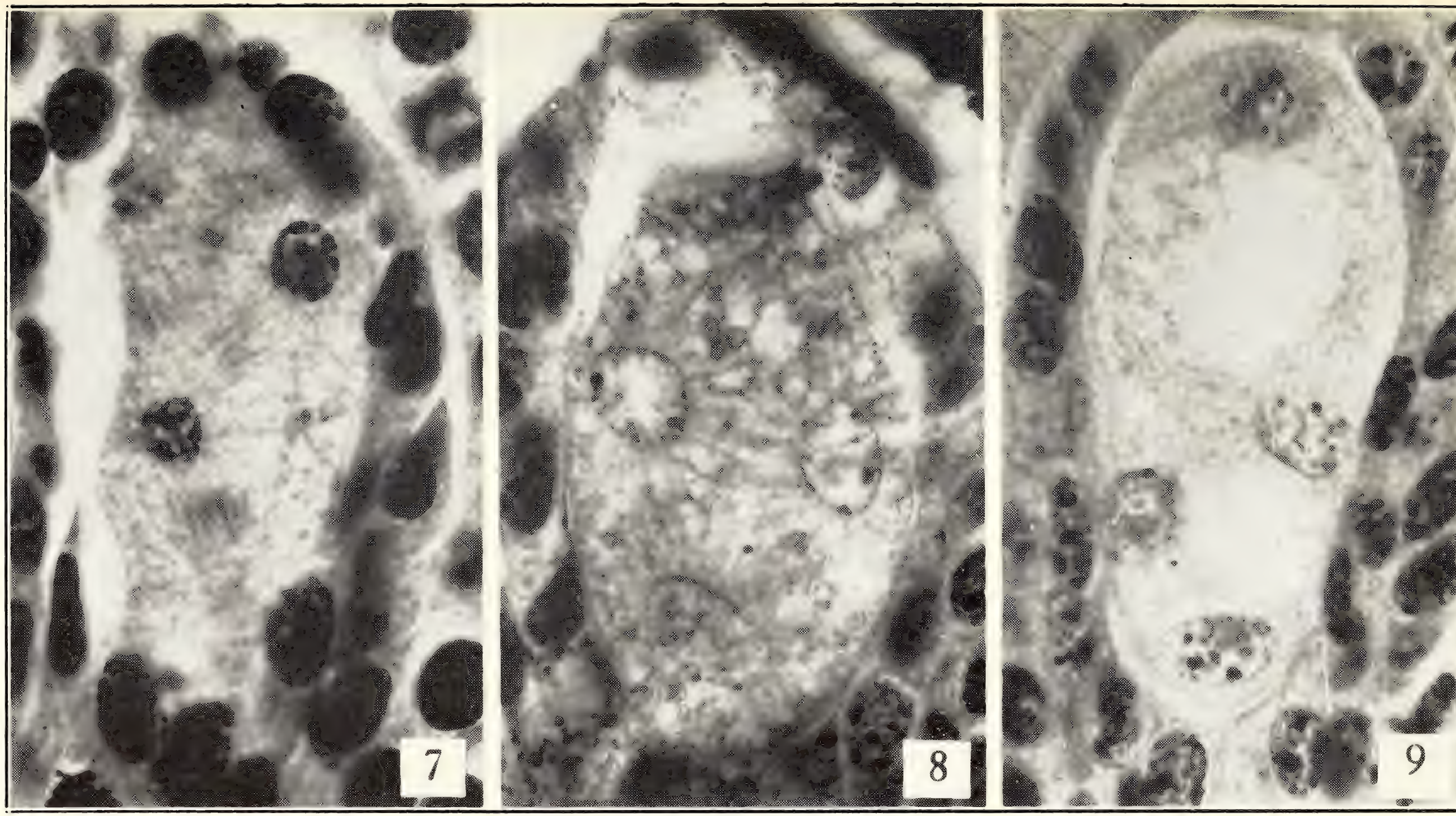

Plate 22. Development of female gametophyte in Erythronium. Fig. 7. *E. helenae*: three of the four haploid nuclei connected by fibers; the chalazal nucleus is in the adjacent section but connecting fibers can be seen. Fig. 8. Four haploid nuclei in *E. helenae* all connected by fibers, some of which are out of focus (see text fig. 1). Fig. 9. Four haploid nuclei of *E. tuolumnense* separated by vacuoles. All $\times 700$.

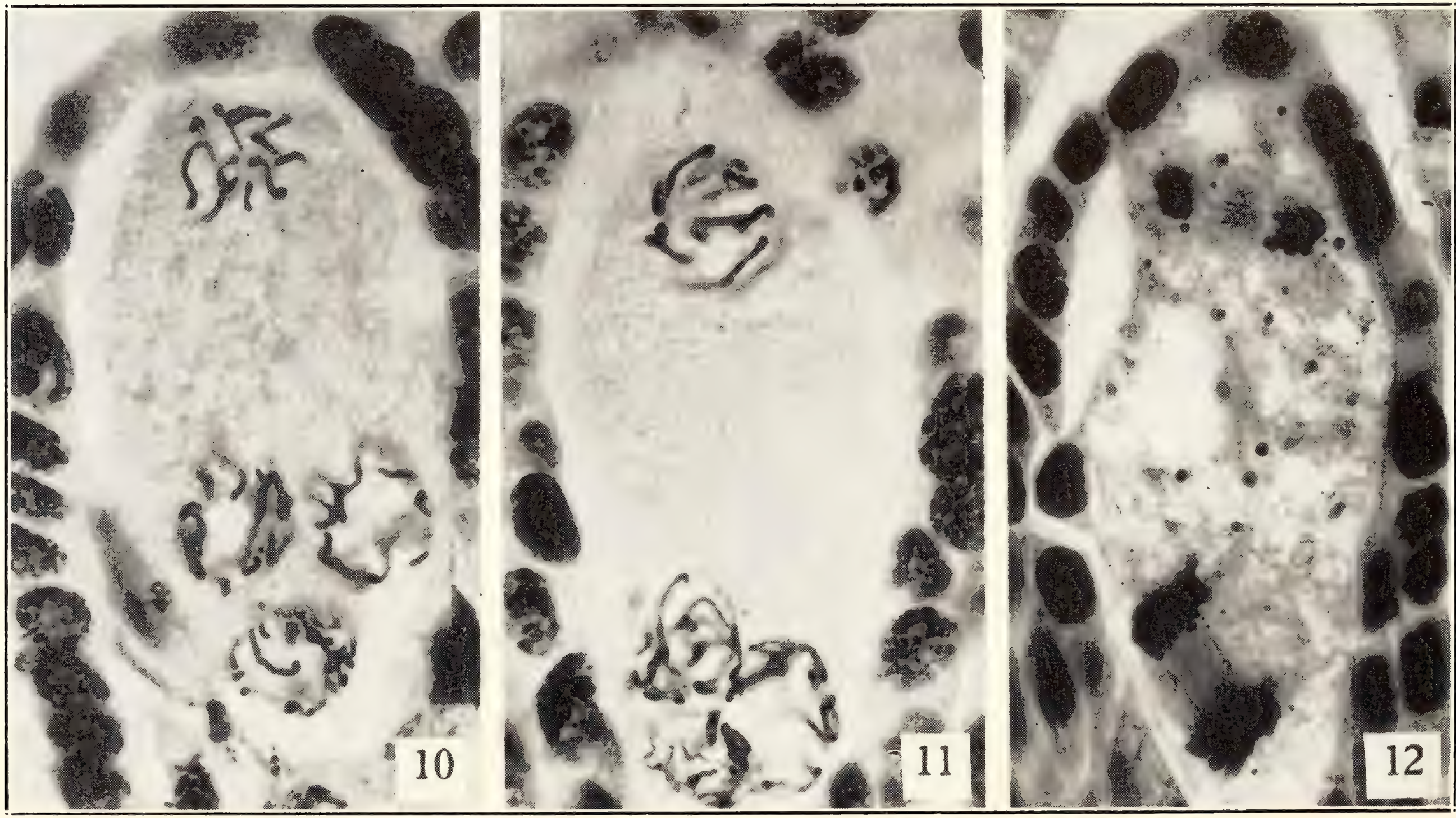

PLATE 23. DEVELOPMENT OF FEMALE GAMETOPHYTE IN ERYTHRONIUM. Fig. 10. Third prophase in *E. helenae*. Fig. 11. Slightly later than Fig. 10; chromosomes of chalazal nuclei becoming aligned on one spindle. Fig. 12. Third telophase in *E. helenae:* note dark bodies and larger chromatin masses at chalazal end. All $\times 700$.

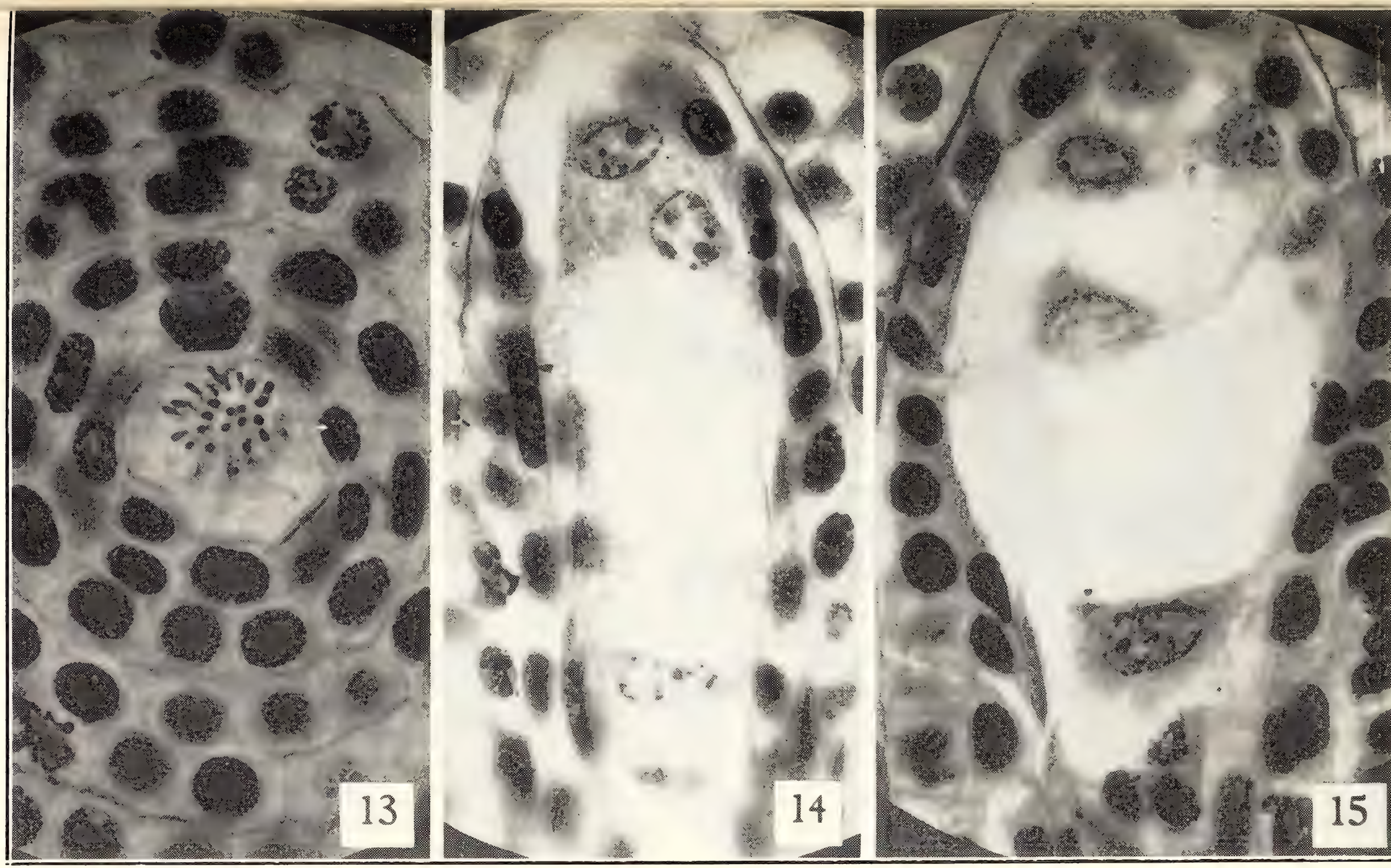

PLATE 24. DEVELOPMENT OF FEMALE GAMETOPHYTE IN ERYTHRONIUM. Fig. 13. Polar view of third anaphase in *E. helenae*. Fig. 14. Second four-nucleate stage in *E. helenae*. Fig. 15. Eight-nucleate female gametophyte of *E. helenae*. All × 500.

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SOME CHEMICAL PROPERTIES OF EUCALYPTUS IN RELATION TO THEIR EVOLUTIONARY STATUS

James B. McNair

This paper presents comparisons of morphological and chemical characteristics of members of the genus *Eucalyptus* and shows that primitive species are primitive both morphologically and chemically and more recent species are advanced both morphologically and chemically. Chemical advance involves oxidation. But chemical and morphological advances do not necessarily progress hand-in-hand.

Baker and Smith (1, 2) after thirty years work classified the genus chemically and phylogenetically. Their phylogenetic ar-

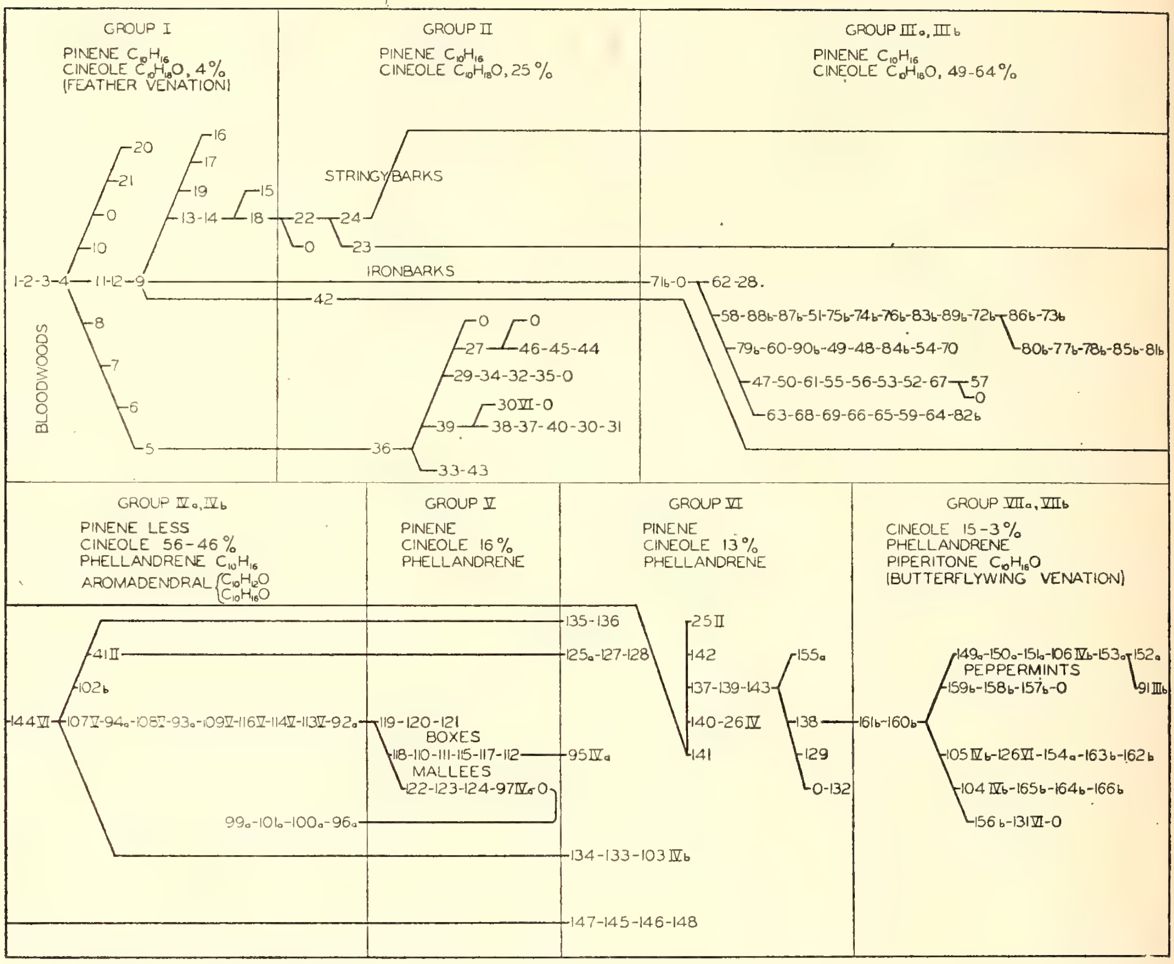

FIG. 1. Phylogenetic tree of *Eucalyptus* species portraying both systematic and chemical relationships.

rangement is shown in figure 1 and their seven chemical groups are given in Table 1. If we consider the groups of Baker and Smith in relation to the phylogenetic tree made by them it is apparent that each group represents a horizontal cross section of their phylogenetic tree (fig. 1) and consequently sometimes includes heterogeneous species which are products of different branches of descent (not natural groups or genetic sequences) and sometimes includes reversions. In other words each Baker and Smith group represents a stratum or phase in the evolutionary development of the genus. So we find (fig. 1) that group II includes three separate natural sequences, 22. *E. Wilkinsonia,* 23. *E. eugenioides,* and 24. *E. umbra* all descendants of 18. *E. nigra;* 42. *E. peniculata* from 9. *E. botryoides;* and 36. *E. maculata* and its numerous following from *E. terminalis.* Group VI has five separate systematic series and in groups IVa and IVb are found examples of natural sequences on a morphological basis which include a variety of interspersed chemical groups. For example 144. *E. obliqua* of group VI chemically is followed morphologically by 107. *E. tereticornis* of group V chemically, followed by 94. *E. tereticornis* var. *cineolofera* of group IV class (a) chemically, etc.

Consequently it is apparent from figure 1 that these plants

may sometimes combine advanced systematic characters with more primitive chemical characteristics, for example, 105 IVb which is chemically in group IV but morphologically in group VII. In still other cases primitive morphological characters seem to have been retained by plants in chemically advanced positions, for example, 114 V between 116 V and 113 V. It may be concluded, therefore, that the development of chemical characteristics and morphological characters do not necessarily proceed hand-in-hand; one may proceed more rapidly or less rapidly than the other. An excellent example of this is seen in the case of *E. dives, E. radiata* and *E. micrantha.*

Eucalyptus dives, the common broad leaf peppermint, occurs in Australia over vast areas and the oil from the leaves has become of importance owing to the occurrence in it of from 40 to 50 per cent of the ketone piperitone, a commercial source of thymol and menthol. With the increased economic demand it was found that certain oils said to be obtained from the leaves of *E. dives* only yielded 5 to 20 per cent of the ketone. These were at first regarded as adulterated. It was, however, shown that they were genuine oils and that *E. dives* existed in at least four varieties which were morphologically absolutely indistinguishable both in the field or in the herbarium. At first sight this difference might be expected to be due to soil or climatic conditions but this is not the case, since the different varieties may grow side by side in the field and breed true when grown in pots (7, 8, 9, 10). The young seedlings from all four kinds were morphologically identical, yet when tiny fragments of the leaves, even from plants only one and one-half inches in height were rubbed between the fingers the characteristic odor of each particular kind was readily detected.

As a result of investigations by Penfold and Morrison (11, 12, 13) extending over a period of ten years it has been found possible to separate morphologically identical trees of *E. dives, E. radiata* and *E. micrantha* into groups as a result of hybridization based upon the chemical composition of the volatile oils.

Interrelationships Between Principal Constituents

The principle constituents of *Eucalyptus* oils are the two terpenes, pinene and phellandrene, the oxide cineole, the group of aldehydes and a ketone known collectively as aromadendral and the ketone piperitone.

Pinene. The pinene occurring in *Eucalyptus* oils is alpha pinene and it is found in two forms, one which deflects a ray of polarized light to the right (dextro) and the other which deflects to the left (laevo).

Phellandrene. This terpene is somewhat extensively distributed in the oils of certain groups of *Eucalypti.* It is more pronounced in those belonging to the more recent end of the genus, and it occurs more abundantly in those species common to the

TABLE 1. AMOUNTS OF PRINCIPAL SUBSTANCES AND PHYSICAL AND CHEMICAL PROPERTIES OF EUCALYPTUS OIL GROUPS (AUSTRALIAN AND TASMANIAN)

	Group No.	Pinene $C_{10}H_{16}$	Cineole $C_{10}H_{18}O$ percentage	Phellandrene $C_{10}H_{16}$	Aromadendral Cuminal $C_{10}H_{12}O$ Cryptal $C_{10}H_{16}O$	Piperitone $C_{10}H_{16}O$	Refractive index 20° C.	Specific gravity 15° C.	Optical activity	Solubility in parts 70–80 per cent alcohol, average
Large Group No. 1	I	large	rare aver. 4.2	absent	....	....	1.4755	0.8863	+13.4	7.8
	II	large	40 – aver. 25	absent	absent	....	1.4705	.9015	+ 5.56	3.6
	III(a)	large	40–50 aver. 49	absent	rare	....	1.4670	.9159	+ 6.1	2.3
	III(b)	large	55 + aver. 64	absent	absent	....	1.4656	.9178	+ 4.28	1.4
Large Group No. 2	IV(a)	diminishing	40 + aver. 56	absent	present	....	1.4677	.9179	+ 0.5	2.6
	IV(b)	....	40 + aver. 46	present	....	....	1.4682	.9119	– 4.5	
	V	present	40 – aver. 16	rare	present	....	1.4800	.9056	– 4.0	2.3
	VI	present	40 – aver. 13	present	....	....	1.4845	.9054	– 7.0	2.1
	VII(a)	....	40 – aver. 15	large	....	present	1.4793	.8863	–32.7	2.0
	VII(b)	....	rare aver. 3	present	....	present	1.4838	.8803	–38.8	

eastern and southeastern portion of the continent of Australia and Tasmania.

CINEOLE. The constitution of cineole is probably that of cinyl oxide, $C_{10}H_{18}O$. It has been described under the names eucalyptol (its most common commercial name) and cajuputol.

When terpin is dehydrated cineole is produced. Cineole is an internal ether produced by the elimination of water between the two hydroxyl groups in terpin. Although we have no direct evidence as to the mechanism of the formation of cineole in plants, its very frequent occurrence in oils containing α-terpinene can be accounted for readily if it be assumed to be formed from either α-pinene or α-terpineol, when terpin may be regarded as an intermediate product (16, 382).

The oils from the group of *Eucalypti* known as "gums" usually contain a fairly large amount of cineole, together with pinene, and in the case of many members belonging to this group, the cineole increases in amount when the oils are stored. This increase in cineole through possible oxidation during storage apparently confirms the fact that cineole is an oxidation product of pinene.

AROMADENDRAL. The term aromadendral is used to denote the presence of one or more members of a group of characteristic aldehydes and a ketone in *Eucalyptus* oils. These aldehydes include cuminaldehyde (cuminal), phellandral and cryptal; they do not seem to occur in the oils of the earlier members of the genus (the pinene yielding group), nor in those of the more recent species, particularly those in which phellandrene is the more pronounced terpene. In these latter species the characteristic constituent is the ketone piperitone.

It may also be stated as a general rule that cymene is present in either larger or smaller amount in the oils of species containing these aldehydes.

Wallach (17) has shown that the oxidation of β-phellandrene produced a glycol, which on treating with dilute H_2SO_4 gives dihydro- and tetrahydrocuminaldehydes. Molecular re-arrangement of a somewhat similar character may perhaps take place naturally.

PIPERITONE. Piperitone is the peppermint ketone of *Eucalyptus* oils. It is an unsaturated ketone $C_{10}H_{16}O$ with one double bond. It appears to occur only in the oils of species occupying the more recent end of the genus and is not found in the oil of any member of the groups occupying the anterior position, in the evolutionary sequence of the genus. In the oils of most species, piperitone is found associated with the corresponding l-rotatory secondary alcohol piperitol. Phellandrene in *Eucalyptus* oils is often associated with l-piperitone, but not always, although it may be accepted that the most pronounced phellandrene *Eucalyptus* oils always contain this ketone in smaller or larger amounts.

Hughesdon, Smith and Read (4) have directed attention to the fact that l-piperitone always occurs in nature in association with

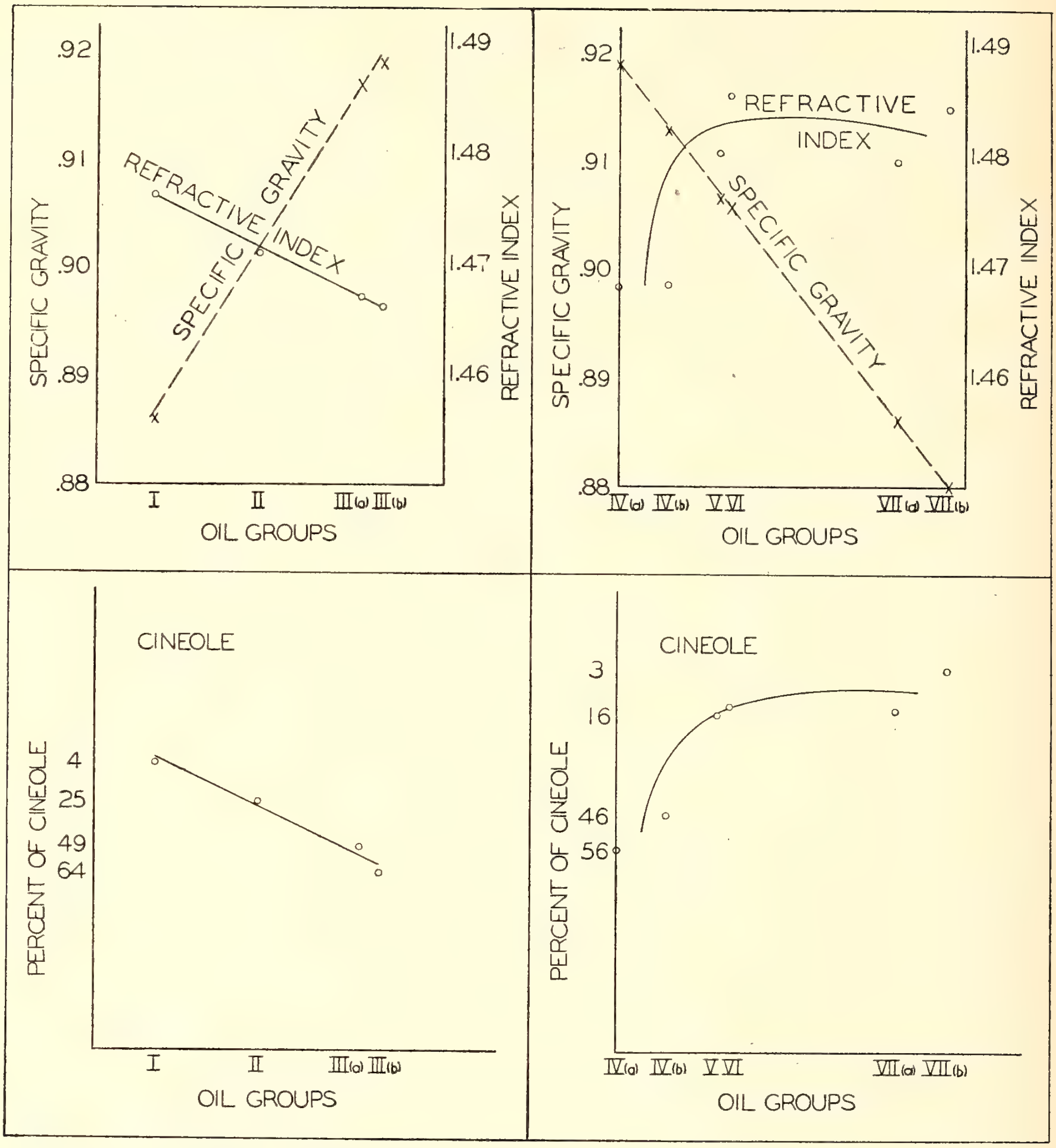

Fig. 2. Graphs showing the specific gravities, refractive indices and percentages of cineole of *Eucalyptus* oil groups.

l-α-phellandrene and l-piperitol and it is possible that some relationship exists between these substances. In the laboratory it has been found that the reduction of either d- l- or dl-piperitone with sodium in alcoholic solution yields dl-isomenthols and dl-menthols, some dl-α-phellandrene being formed simultaneously.

Comparison of Specific Gravities and Refractive Indices

Based on their specific gravities (and concomitant refractive indices) *Eucalyptus* oils may be divided into two large groups. The first and most primitive group includes groups I, II, IIIa and IIIb of Baker and Smith (2). (Table I and text fig. 2).

The second and less primitive group includes groups IVa, IVb, V, VI, VIIa and VIIb of Baker and Smith (2).

In figure 2 it so happens that a straight line will pass near all

the points representing the specific gravities of groups I to IIIb inclusive and that another straight line will pass near all the points representing refractive indices. Therefore, the rule that a high specific gravity is accompanied by a low refractive index and vice versa for plant volatile oils (5) is confirmed.

It is noticeable that a straight line cannot be drawn through all of the five points representing the refractive indices of groups IV to VIIb, and that the line of closest fit is a curve. Consequently it is obvious that the mixture of substances which constitutes the volatile oils of at least some of the members of this group are different from those of the groups I to IIIb where straight lines can be drawn approximately through all the points representing the specific gravities and another straight line will lie near to all of the points representing refractive indices. Different mixtures of substances are also indicated in figure 2 by the fact that for groups I to IIIb the refractive index decreases with advance in plant evolutionary position while for groups IV to VII the reverse is true. Likewise there is a difference in the directional change in specific gravities for groups I to IIIb and IV to VII. In groups I to IIIb the specific gravity increases with advance in plant evolutionary position while in groups IV to VII the reverse takes place.

Increase in Oxygenated Bodies with Evolutionary Progress

According to the general theory for angiosperm volatile oil behavior, the specific gravity should increase and the refractive index should decrease with advance in evolution (6). The oils of groups IVa to VIIb contain principally pinene, its oxidation product cineole, and phellandrene and its oxidation products, cuminal, cryptal, phellandrol and piperitone. From Table 1 it is seen that pinene and cineole are diminishing while the other substances mentioned are increasing with progress from IVa to VIIb. The removal of a heavy substance from the oil would decrease its specific gravity. Therefore the subtraction of pinene which has a specific gravity of 0.865 at 15 degrees would not tend to decrease the specific gravity of the oil because its specific gravity is lower than that of the average specific gravity of groups IVa to VIIb (Table 1). However, if cineole be taken out the specific gravity would tend to lower because cineole with its specific gravity of 0.930 at 15 degrees is greater than the average specific gravity of the oils of the groups here considered. The content of cineole rapidly diminishes (56 per cent to 3 per cent) in these groups. The other main oxygenated bodies of these groups also have specific gravities near that of cineole. Consequently neither the amounts of these compounds nor that of cineole increases from groups IVa to VIIb enough to change the diminishing trend of the specific gravity. Should the total amount of the oxygenated bodies increase from IVa to VIIb it is obvious that the specific

gravity would also increase. Consequently we may conclude that the volatile oils of *Eucalyptus* species when in their native habitat, increase in specific gravity with the increase in plant evolution *except* where the oxygenated bodies decrease in amount with the increase in evolution.

The refractive index of cineole (1.4596 at 20 degrees) is lower than the average refractive index for the group oils. Consequently its removal would tend to raise the refractive index of the group oils. Otherwise the refractive index would increase with evolutionary progress.

Table 1 shows that chemical analysis has found the number and variety of oxidation products to increase with advance in evolutionary position in the genus. Cineole, the oxidation product of pinene, is found in all of the groups. Aromadendral (which is mostly cuminal and cryptal oxidation products of phellandrene) is found in groups III, IV and V. Piperitone with which is associated phellandrol, both oxidation products of phellandrene are found in group VII.

The increase in the number and variety of oxidation products is likewise shown by the increase in the solubility of the crude oils in 80 per cent alcohol from groups IVa to VIIb (Table 1). For the oxidation products are soluble in alcohol whereas the terpenes, pinene and phellandrene are comparatively insoluble. The amount of cineole rapidly decreases from group IVa to VIIb and yet the solubility increases. Consequently some other oxidation products must replace the removed cineole.

Optical Rotation

A glance at Table 1 shows clearly that the average optical rotation becomes more laevo-rotatory as the evolutionary sequence of the groups advance. There are a number of dextro- and laevo-rotatory substances in the oils. There are present in varying amounts both dextro- and laevo-pinene and d- and l-phellandrene. There are also l-piperitone, d-terpinol and d-eudesmol. Most of the pinene is dextro- and most of the phellandrene is laevo-rotatory; d-pinene accounts for the predominant d-rotation in groups I, II, IIIa and IIIb and l-phellandrene and l-piperitone for the predominant l-rotation in the remaining groups.

Ontogeny and Phylogeny

The *Eucalypti* furnish an excellent chemical counterpart to the morphological theory of Haeckel (3) that ontogeny recapitulates phylogeny, that the organism in its development is to a great extent an epitome of the form modifications undergone by the successive ancestors of the species in the course of their historic development. Oil from the younger seedlings contains more d-pinene and less cineole (that is more hydrocarbon and less oxygenated products) than does that from the saplings two or three

years old, and the maximum cineole content is reached in the oil collected from older trees (2). This is true also for the leaves which are reproduced from lopped old trees, and the oil from seven months "suckers" contains more cineole and less pinene than does that from twelve months old seedlings, while that from fifteen months old "suckers" follows the same rule in respect to two and one-half year old seedlings. The increase in the amount of cineole with progress in evolution in Large Group No. 1 of the genus is shown in Table 1.

Summary

There has been orderly evolution in volatile oil characteristics of the *Eucalypti* which may be correlated with changes in morphological characteristics. However, oil groups represent cross-sections of the phylogenetic tree and not necessarily genetic sequences or natural groups of the systematist. Botanically distinct species are generally distinguished by their chemical constituents and also in some cases where morphological examination shows little or no difference, chemical analysis of the oil reveals the existence of completely distinct varieties.

With progress in evolution the amount of the hydrocarbon (terpene), pinene and its oxidation product cineole increase to a maximum, then decrease; another hydrocarbon (terpene) phellandrene and its products form a second series of compounds which is evidenced first by the appearance of aromadendral (an aldehyde and ketone mixture containing cuminaldehyde and cryptal); next phellandrene becomes a pronounced constituent and finally its ketone piperitone increases in amount.

The specific gravity increases with the increase in plant evolution, and the refractive index decreases with the increase in plant evolution, except where the oxygenated bodies decrease in amount with the increase in evolution.

The number and variety of oxidation products increase with advance in evolutionary position in the genus.

There is a tendency for the optical rotation to become more laevo-rotatory with advance in evolution caused principally by a decrease in d-pinene and an increase in l-phellandrene and its ketone l-piperitone.

Morphological and chemical phylogeny have their counterparts in ontogeny.

Los Angeles, California,
July 3, 1941.

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GRASSLAND AND RELATED VEGETATION IN NORTHERN MEXICO

Forrest Shreve

The extensive grassland area of the central United States exhibits its optimum development in Kansas and Nebraska, and extends south to the Mexican boundary only after suffering localization in occurrence and modification in character. The plains and gently falling outwash slopes of southern New Mexico and western Texas are largely occupied by a very open type of arid grassland in which *Yucca, Nolina, Dasylirion, Agave, Opuntia* and various shrubs are conspicuous. This is a transition region, in which the conditions are intermediate between the optimum ones for grassland and for desert. The vegetation is formed by an infiltration of plants from each of these vegetations, with very few dominant species that are distinctive of the transition region. In both of the states mentioned and also in southeastern Arizona there are areas of true grassland growing in favorable valleys or

circling the higher mountains, and in all cases occupying relatively deep soils at elevations of 1500 to 1800 meters.

At higher elevations in northern Mexico, where climatic and soil conditions are favorable, there are some large areas of grassland. These are chiefly along the eastern base of the Sierra Madre Occidental and around the higher mountains of northern Coahuila. Grasses are also important in the transitions from grassland to encinal (evergreen oak woodland), to juniper or pinyon woodland, and to oak chaparral. Grasses are likewise important in the cactus-acacia-grassland ("cactus savanna"), which lies between the southernmost areas of desert and the grassland. In northern Chihuahua there are a number of "llanos," or grass covered plains, which are not related to the true grassland and its transitions but are distinctly a desert association occurring also in Arizona and Sonora. The aim of this paper is to describe briefly each of these types of vegetation in which grasses play a conspicuous part. Nothing will be said here in reference to the minor rôle played by grasses in the desert, their greater importance in the arid bushland which occupies the low elevations of northeastern Mexico, nor their secondary rôle in the forests of northern Mexico.

Prior to the beginning of the Madero revolution the grasslands of northern Mexico were a source of great wealth. The destruction and expropriation of most of the great cattle ranches gave the grasslands a period of over fifteen years with relatively light utilization. During the last seven years the agrarian program of the Mexican Government has brought some of the best areas of grass into cultivation. A magnificent natural sod has been destroyed in a worthy effort to help inexperienced and poorly equipped farmers to raise profitable crops of corn by dry farming methods. The recent heavy importation of foodstuffs by Mexico, for the first time in its history, is eloquent proof of the difficulties which this program has encountered.

The most extensive grasslands are in central Chihuahua, covering an area indicated on the map accompanying a paper by the writer in this journal (4). A continuous belt of varying width extends south through Durango and Zacatecas into Aguascalientes and northern Jalisco. Most of these areas are in the elevated valleys which lie between the eastern base of the Sierra Madre and the subsidiary ranges which parallel it on the east. In northern Chihuahua grassland is found in suitable situations between elevations of 1600 and approximately 2150 meters. In northern Durango there is a very gradual ascent from the central basin of the Mexican plateau to the summit of the Cuchillo de Zarca at 2000 meters. On this ascent in the region west of Mapimi the desert shrubbery is gradually replaced by grasses, and typical grassland is first met slightly below 1800 meters. In southern Durango, south of the Rio Nazas, grassland is first encountered at 1925 meters and covers a large area in the central

and southern part of the state. Between Nombre de Dios, Durango, and Sombrerete, Zacatecas, broad grassland valleys rise to an elevation of 2500 meters. Similar areas also extend north from the city of Durango but are interrupted by extensive malpais areas. In the 1000 kilometers between northern Chihuahua and central Zacatecas it will be noted that there is a slight increase in the elevations between which grassland is found. In northern Coahuila the scattered belts of grassland lie between 1500 and 1800 meters.

The western face of the Sierra Madre Occidental is more precipitous than the eastern and active denudation has prevented the development of large areas suitable for domination by grasses. In northeastern Sonora there are areas and belts of grassland in localities north of Moctezuma and east of Magdalena. With decreasing altitude the transition from grass to desert is rapid. South of Moctezuma the principal display of grasses is in foothills at elevations of 450 to 900 meters, where coarse bunch grasses grow in the open stands of oak. The Sonoran grasslands are rich in species but differ in composition from the areas in Texas and Chihuahua.

On the eastern side of the Mexican plateau, along the western base of the Sierra Madre Oriental, the physical conditions differ greatly from those on the western side. The mountain axis is not so continuously elevated and has no parallel subsidiary ranges on its landward side. The highest peaks are Cerro Potosi (3800 m.) and Peñon Nevado (3664 m.). Between them, and north of the former, are gaps so low that many desert plants extend over the divide into the drainage of the Gulf of Mexico. Another important feature with reference to grassland is the prevalence of limestone along the mountain front in Coahuila and Nuevo Leon. The reluctant weathering of limestone leaves the soil shallow, the surface stony and the deep pockets of soil few. In Mexico, as in the southwestern United States, the limestone soils do not support heavy stands of grass, and desert invariably extends to much higher elevations on limestone than on other types of rock and their derived soils.

The nearest approach to areas of typical grassland on the eastern side of the plateau has been found between Mier y Noriega and Soledad, Nuevo Leon, in the lee of the Peñon Nevado range. The elevation ranges from 1700 to 2000 meters and the rainfall at a single adjacent station is 500 millimeters. On the pediments and gently rounded ridges which parallel the base of the mountains the cover is rarely more than 50 per cent grass, the remainder being other herbaceous perennials. There are frequent mottes of *Quercus cordifolia* from 5 to 6 decimeters high, as well as other shrubs and semi-succulents of greater frequency than in typical grassland.

The characteristic grasses in this region are *Bouteloua gracilis*,

FIGURE 1.

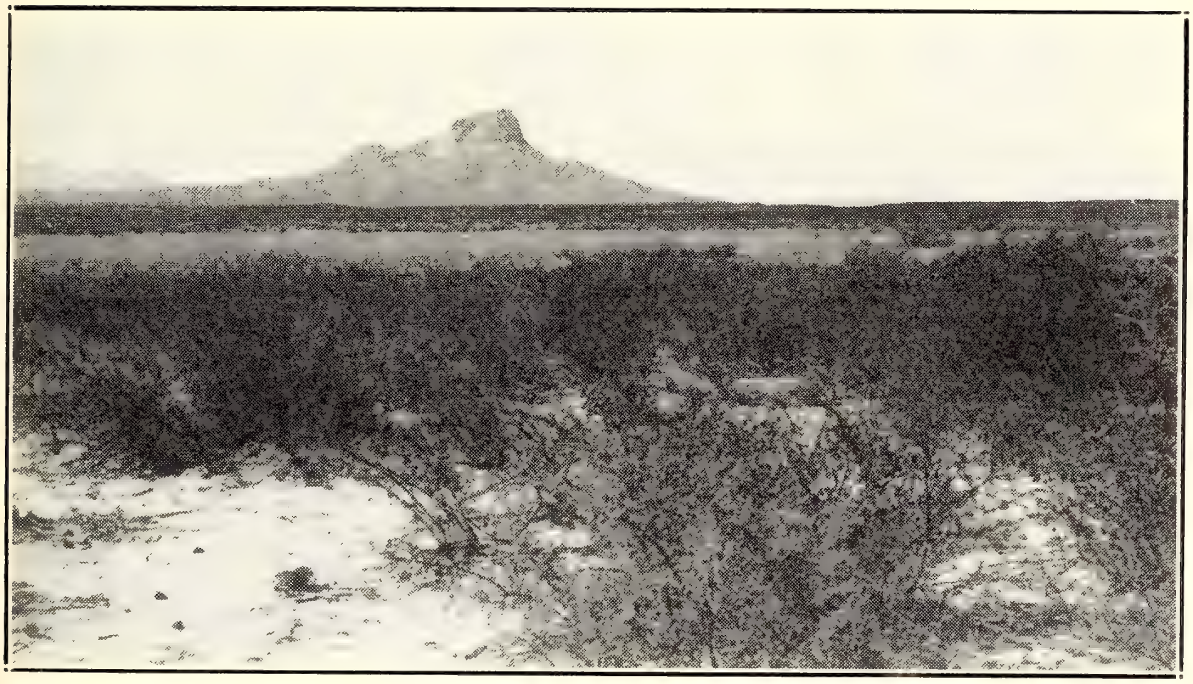

FIGURE 2.

PLATE 25. GRASSLAND IN NORTHERN MEXICO.

PLATE 25. GRASSLAND IN NORTHERN MEXICO. Fig. 1. Looking northeast across the grassland plateau of southern Durango from the lower edge of pinyon woodland in mountains near La Purisima, at 2400 meters elevation. Fig. 2. Looking across bajada with desert shrubbery of *Larrea* and *Acacia vernicosa* to small *Hilaria* llano, 65 kilometers northeast of Camargo, Chihuahua, at 1400 meters elevation.

Triodia grandiflora, Hilaria cenchroides, Lycurus phleoides, and a small slender form of *Bouteloua curtipendula.* The commonest associated plants are *Zinnia anomala, Dichondra argentea, Dyschoriste decumbens, Dyssodia setifolia, Acalypha phleoides, Florestina tripteris* and *Houstonia rubra.*

The precipitation in the Mexican grassland lies approximately between 400 and 500 millimeters on the west side of the central basin and between 500 and 600 millimeters on the east side of the mountains of northern Coahuila. The annual average for the city of Chihuahua, just below the edge of the grassland, is 385 millimeters, while for Parral, just above the grassland, it is 517 millimeters. In the city of Durango the average rainfall is 463 millimeters and at Villa Madero it is 488 millimeters, both localities being in cultivated country that was originally grassland. Charcas, San Luis Potosi, is at 2060 meters elevation on the eastern edge of the grassland, which is only locally and poorly developed there. The average annual precipitation at Charcas is 411 millimeters. Throughout the grassland areas the late winter and spring are dry and the four months, June to September, receive from 64 to 77 per cent of the annual precipitation.

The areas herein designated as grassland are occupied by "short" grasses forming a sod or turf which covers 80 per cent or more of the surface. Cacti over 20 centimeters in height, shrubs and trees are rare or absent. *Yucca, Nolina, Dasylirion* and *Hechtia* are infrequent except at the lowest altitudes and in the transition from grassland to desert. Closely associated with the grasses is a large number of herbaceous root perennials, many of which are prostrate, low, or of habit and leaf size which make them inconspicuous.

The structural and social features of the Mexican grasslands resemble those of the central United States, as described by Clements (1), Weaver and Fitzpatrick (5), Gates (2) and others. The floristic composition is similar to that of western Texas but differs materially from that of Kansas. Among the characteristic grasses of the latter state *Agropyron Smithii, Eragrostis spectabilis, Sporobolus asper, Aristida oligantha, Scheddonardus paniculatus, Stipa spartea* and *S. comata* are absent or very uncommon in Mexico. *Andropogon scoparius* is absent and *A. furcatus* is widespread but nowhere abundant. *Koeleria cristata* is abundant only at high elevations in the grassy forests.

Throughout the most extensive grass areas of Chihuahua and Durango the species of *Bouteloua* greatly dominate over the representatives of other genera. The commonest of these is *B. gracilis,* which is estimated to form at least 80 per cent of the cover in approximately 60 per cent of the grassland area. In the southern extension of the grassland, in Zacatecas and Jalisco, *Bouteloua hirsuta, B. radicosa, Hilaria cenchroides* or *Sporobolus trichodes* alternate or associate as the most common species. Throughout the grassland area large coarse grasses occur spo-

radically or in isolated colonies, including *Andropogon saccharoides, A. barbinodis, Stipa eminens, S. clandestina, Sporobolus airoides, Elyonurus tripsacoides* and *Trichloris mendocina.* Relatively moist areas are heavily carpeted by *Buchloë dactyloides.* Dry localities with shallow soil at low elevations are thickly covered with *Triodia pulchella* or well defined colonies of *Scleropogon brevifolius.* In general, however, the grasslands are as monotonous in composition as they are in their physiognomy.

The following list includes the dominant and frequently recurring grasses of the grassland areas of northern Mexico. The names are approximately in the order of abundance.

Bouteloua gracilis	Andropogon saccharoides
Bouteloua curtipendula	Aristida ternipes
Bouteloua chondrosioides	Eragrostis lugens
Aristida divaricata	Eragrostis intermedia
Eragrostis mexicana	Hilaria cenchroides
Bouteloua radicosa	Muhlenbergia monticola
Triodia pilosa	Stipa editorum
Stipa eminens	Triodia mutica
Eragrostis diffusa	Scleropogon brevifolius
Lycurus phleoides	Sporobolus trichodes
Buchloë dactyloides	Pappophorum Wrightii
Triodia grandiflora	Setaria macrostachya

Grasses which are less abundant over the entire area or only locally common are the following.

Andropogon perforatus	Muhlenbergia rigida
Aristida adscensionis	Panicum Hallii
Aristida glauca	Panicum obtusum
Aristida hamulosa	Setaria geniculata
Bouteloua eriopoda	Setaria Grisebachii
Bouteloua filiformis	Sporobolus airoides
Bouteloua hirsuta	Sporobolus Poiretii
Bouteloua Rothrockii	Stipa clandestina
Elyonurus tripsacoides	Stipa tenuissima
Eragrostis limbata	Trichloris mendocina
Leptochloa dubia	Triodia grandiflora
Muhlenbergia polycaulis	Triodia pulchella

Transition from Grassland to Encinal

At the same altitudes occupied by grassland there also occur extensive stands of encinal (evergreen oak woodland) or open stands of juniper or pinyon. These are almost invariably confined to hills and abrupt slopes or to rocky ground with shallow soil, while grassland occupies level or gently sloping areas with soil from 15 to 50 centimeters or more in depth. In open stands of woodland the floor supports a light cover of grasses which

differs little in appearance and composition from pure grassland. Where the soil is rocky and irregular in depth, and the trees are abundant, a rich variety of herbaceous perennials forms more of the cover than do the grasses.

In central Chihuahua the lower edge of the encinal is often encountered at 1500 meters in very open stands of *Quercus chihuahuensis, Q. santaclarensis* or *Q. Emoryi.* In southern Durango encinal fails to find extensive areas of suitable conditions below 2150 meters, and in several districts grassland extends up to 2500 meters. In both states the texture and depth of soil appear to be the deciding conditions for the dominance of grasses or the appearance of trees. The critical season for trees is the dry period extending from February to May. Nothing is known about the comparative soil moisture of the deep soils and the rocky terrain in this region. If conditions are analogous to those investigated in Arizona the pockets and layers of the rocky soil have a higher moisture content in dry periods than the deep uniform soil has. All evergreen oaks defoliate in the early spring and simultaneously form a complete new crop of leaves. In Chihuahua in 1937, after a dry winter and delayed summer rains, the oaks were nearly leafless in July and new leaves first began to appear early in August. Even in their more favorable habitat the oaks must often be thus brought near the margin of their drought resistance. At such times they might not be able to survive on deep level soil except near streamways.

In northern Coahuila the upper edge of the grassland commonly merges into shrubbery from 1 to 2 meters in height. This vegetation forms a closed cover at slightly higher elevations and on north slopes. It so closely resembles the Pacific coast chaparral in its life forms, social aspects, and generic composition that it may well be designated by the same name. The Mexican chaparral has been described by Muller (3) as manifested on the lower western slopes of Cerro Potosi, in Nuevo Leon. The lower, open edge of the chaparral is dominated in Coahuila by shrubby oaks, notably *Quercus invaginata, Q. cordifolia, Q. Pringlei, Q. hypoxantha,* and *Q. intricata,* or else by small individuals of arborescent species. Commonly associated with the oaks, or locally outnumbering them, are *Cowania plicata, Arctostaphylos pungens, Microrhamnus ericoides, Ceanothus lanuginosus, Mimosa biuncifera, Amelanchier denticulata, Rhus microphylla, Berberis trifoliata* and *Cercocarpus mojadensis.* The prevailing limestone of northern Coahuila is not favorable to the attainment of large size by oaks and pinyons. On steep and moderate slopes the chaparral forms heavy stands and grasses are nearly absent. On level ground and gentle slopes the shrubbery is open and there is a ground cover of grasses and herbs. These circumstances bring about considerable variation in the altitude at which grassland merges into chaparral, and at which chaparral becomes dominant. The changes

most commonly take place between elevations of 1500 to 1800 meters.

Cactus-Acacia-Grassland

Along its southwestern margin the Chihuahuan Desert is bounded by a distinctive type of vegetation which lies between the desert and grassland. This is essentially a thin cover of short grass with a continuous open stand of small trees and tall platyopuntias. The striking physiognomy of this vegetation might suggest that it be designated by the loosely used term "savanna," which is often misapplied to any association of grasses and trees. True savanna is characterized by large harsh-leaved grasses of a type which rarely forms closed communities in temperate North America. The characteristic tree is *Acacia tortuosa,* which usually has a broad flat crown, and the only other tree is a much less frequent undescribed species of *Prosopis.* The platyopuntias are *Opuntia streptacantha* and *O. durangensis,* which are erect, have broad joints 30 to 40 centimeters long, and reach a height of 3 to 6 meters. The cacti usually outnumber the trees but are widely spaced or in open groups. Shrubs are very uncommon and nearly limited to *Celtis pallida* and *Acacia paucispina.* Semi-succulents are sparingly represented by *Yucca carnerosana,* which reaches a height of 5 to 12 meters. Cacti other than those mentioned are very uncommon, the one most frequently seen being the ubiquitous *Opuntia imbricata.* The representation of grasses corresponds closely with that found in the open grassland. Herbaceous perennials are more abundant in species and individuals than they are in the grassland. Many perennial herbs and several grasses grow in the cactus-acacia-grassland which are not found in the grassland. These are largely confined to the heavy shade of the tall opuntias, whereas the light shade of *Acacia,* which executes considerable movement during the day, is occupied by the prevailing sod.

It seems scarcely allowable to regard the cactus-acacia-grassland as a transition between desert and grassland. In physiognomy it carries no suggestion of either. It has most of the typical grasses of the grassland but its flora includes none of the characteristic plants of the desert except the occasional trees of *Prosopis.* Also, the three characteristic large plants are found neither in desert nor grassland.

The lower edge of the cactus-acacia-grassland is reached at about 1800 meters and its upper edge at 2000 meters, or exceptionally as high as 2200 meters. It is found only on plains, bajadas and gently rolling surfaces with soil at least 1 to 2 meters deep. The commonest type of soil is a ruddy brown clay of volcanic origin, containing from 5 to 20 per cent of well worn rock particles from 0.5 to 3 centimeters in diameter. In two localities typical stands were seen on granitic loam (near Sain Alto and near Pinos, in Zacatecas).

This type of vegetation has been observed only in southern Durango, Zacatecas, northern Jalisco and southern San Luis Potosi. It has been studied between Yerbanis and Villa Madero, Durango, between Victoria, Durango, and Rio Grande, Zacatecas, between Concepcion del Oro and Santa Maria Mañon, and near Pinos, in Zacatecas, and in the District of Lagos, Jalisco. The principal variations from the typical conditions described are east of Santa Maria Mañon, where the two opuntias form an unusually close stand, and near Arriega, San Luis Potosi, where the opuntias are dense but not more than 2 meters high, and the sod of grasses very open.

There are no available rainfall records within the range of this vegetation but the annual total can be interpolated as probably between 350 and 425 millimeters.

The most abundant herbaceous perennials of the cactus-acacia-grassland are the following.

Dichondra argentea	Stevia salicifolia
Evolvulus alsinoides	Commelina scabra
Alternanthera repens	Oxalis albicans
Sanvitalia ocymoides	Zornia diphylla
Plantago mexicana	Cassia crotalarioides
Guilleminea densa	Tagetes lucida
Spergularia mexicana	Acalypha neomexicana
Ipomoea costellata	Dyschoriste decumbens
Drymaria arenarioides	Verbena teucriifolia
Cyperus seslerioides	Phaseolus heterophyllus
Gaura coccinea	Polygala compacta
Tetraclea Coulteri	Sisyrinchium tenuifolium

Many of these plants are familiar components of the grassland as far as northern Chihuahua and western Texas, and it is noteworthy that the list includes no plants of southern range which are here near their northern limits. The grassland and its variants are here near their southern limit, and also many of their characteristic plants reach the southern end of their ranges in Jalisco.

The Hilaria Llanos

Nearly every map of Mexico indicates that the center of the northern plateau is occupied by a single extensive undrained basin, styled the "Bolson de Mapimi." As a matter of fact the area includes a large number of independent undrained basins, or bolsons, varying from a few hundred to several thousand hectares in size. Along the eastern and western edges of the plateau there are an undetermined number of bolsons which receive copious drainage waters from the slopes of the bordering mountains. The centers of these bolsons are occupied by alkaline flats and seasonal lakes. Other bolsons in the center of the plateau receive limited drainage from their surrounding hills and bajadas and are without a central playa, or lake bed. In these

the floor of the bolson is nearly level and the soil is deep and fine in texture. In such situations are found the llanos, or nearly pure *Hilaria* grassland areas, which collectively cover a large expanse in northern Chihuahua. The largest are the "Llano de los Gigantes" and the "Llano de los Christianos," which are the northernmost ones that have been observed. The southernmost one that has been noted is north of Naica, in the district of Meoqui, Chihuahua. The elevation ranges from 1100 to 1300 meters.

As previously intimated the llanos are not to be regarded as part of the climatic grassland formation but rather as a desert association controlled by soil conditions. Surrounding and overlooking the llanos are invariably long outwash slopes covered with typical desert of *Larrea, Flourensia, Acacia vernicosa* and many cacti. Smaller llanos of the same character occur under very similar conditions in southern Arizona and northern Sonora, down to elevations less than 300 meters.

From 80 to 90 per cent of the cover in the llanos is formed by *Hilaria mutica,* growing continuously or in close-set tussocks. On the higher llanos there is often a small percentage of *Bouteloua gracilis* and *B. eriopoda.* There are a few very common non-gramineous associates, including *Florestina tripteris, Viguiera phenax* and *Xanthocephalum gymnospermoides.*

In addition to the regions that have been briefly described in this paper there are at least two other types of vegetation in Mexico in which grasses play a prominent part. One of these is the arid bushland of the low plains of Nuevo Leon and northern Tamaulipas, in which the open shrubbery may or may not be carpeted with annual and perennial grasses. The other is the coastal belt of Vera Cruz, with its tall coarse grass areas merging into marshes or into savanna. Neither of these vegetations has received the ecological investigation which they merit. They have little in common with the grassy areas of the highlands, either in ecological features or in floristic composition. The ecological importance of the grass family in northern Mexico may be surmised from its wealth, for in the ten states north of the Tropic of Cancer nearly five hundred species are known.

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CHAPARRAL

F. P. Cronemiller

Chaparral is a term commonly used in California for the dense brushfields of the Upper Sonoran life zone. This cover type is similar to the *macchie* and *garique* of the Mediterranean region and is a product of the set of climatic conditions peculiar to these areas. Its shrubby components have been termed quite accurately broad sclerophyll vegetation. The purpose of this paper is to give a chronicle of the derivation of the term "chaparral" and to encourage its use and adoption by the technician.

Chaparral evolved from *chabarra,* the Basque word for a scrub oak of the Pyrenees. The Spaniard adapted it to "a dwarf evergreen oak" and spelled it *chaparro.* He did not develop the word "chaparral," however, as he used the term "*garique*" for the cover type composed of this and species of similar growth. On his arrival in the New World he was faced with a tremendous job of inventing place names. The vast number of saints furnished an abundance of names for important places, while descriptive terms were given those of secondary importance. The convenient suffix *-al,* meaning "place of," naturally was often used. *Pinal, alisal, sausal,* designated pine groves, sycamore flats, and willow thickets. For the cover types of dense evergreen scrub oaks, *chaparral* was invented. Quickly the term came to be applied to similar cover types, and this is its usage today. Colloquially it has been applied to individual species such as one of the *Acacia* species in Mexico and to *Ceanothus cuneatus* in California. Generally the proper meaning has adhered: a place (cover type) of evergreen shrubs or dwarf trees.

In addition to chaparral the Spanish Californian used a term, *chamiso* (or *chamisal*), to designate open brush areas composed of small shrubs. The original term, *chamiza,* meant simply "kindling wood." It is not certain that he ever got entirely away from this connotation, but the vaquero used it in opposition to chaparral. To him chaparral was that kind of brush one could not ride a horse through; through *chamiso* or *chamisal,* one could. Californians have anglicized the word to "chamise" and applied it to but a single species, *Adenostoma fasiculatum.* In New Mexico, chamiso refers to *Atriplex canescens,* and in Mexico to other species and types. It would appear that the term "chamise" is hardly tenable, although widely used by the layman and some technicians.

Chaparral is without doubt a needed word; it is in general use, and is recognized by Webster and other lexicographers. The technician should not hesitate to use it.

United States Forest Service,
San Francisco, California,
February 25, 1942

NOTES ON POLEMONIACEAE

Herbert L. Mason

Gilia inconspicua Dougl. ex Hook. Bot. Mag. pl. 2883. 1829, *nomen confusum. Ipomopsis inconspicua* Smith, Exot. Bot. pl. 14. 1805. *Cantua parviflora* Pursh, Fl. Am. Sept. 2: 730. 1814. *Gilia parviflora* Spreng. Syst. Veg. 1: 626. 1825.

In the year 1805 J. E. Smith published in his "Exotic Botany" the name *Ipomopsis inconspicua* based upon plants cultivated in England. The plants were "raised in 1793 by Mr. Thos. Hoy, F. L. S. at Sion House, from seed brought, if I mistake not, from America. Mr. Sowerby sketched it in November of that year." Pursh, in 1814, transferred *I. inconspicua* Smith to the genus *Cantua,* renaming it *C. parviflora.* However, his doubt as to its origin in North America was expressed in the following words, "I insert this plant on the authority of Exotic Botany; but at the same time I doubt very much of its being a native of North America, and more strongly suspect it to come from Mexico." Sprengel transferred the species to *Gilia* in 1825 making the combination *G. parviflora* (Pursh) Spreng., reporting it from North America and citing *Cantua parviflora* Pursh and *Ipomopsis inconspicua* Smith as synonyms. Hooker in 1829 published a manuscript name of Douglas whereby Douglas referred *Ipomopsis inconspicua* Smith to the genus *Gilia* as *G. inconspicua* (Smith) Douglas. All three of the above mentioned names were cited as synonyms. Hooker's remarks are enlightening, "Of the authors who have hitherto described this plant, Smith alone has seen specimens which were cultivated at Sion House, in 1793, from seed which he supposed to be brought from some part of America. Pursh imagined it to be a native of America: but it was reserved for the indefatigable Mr. Douglas to determine its exact locality. He discovered it in the woodless tracts, or sandy barrens on the Southern branches of the river Columbia, on the Northwest coast of America, growing under the shade of *Purshia* (*Tigarea.* Ph.) *tridentata* and some species of *Artemisia.*"

The descriptions by Smith and by Hooker are each accompanied by illustrations in color. It is obvious that the plants illustrated in each case are the same species. It is also obvious that the plants illustrated are not of a type known as yet from the interior of the Columbia River region in northwestern America. Nor does Hooker's illustration agree with the Douglas specimen in the Hooker Herbarium labeled in Hooker's handwriting *"Gilia inconspicua* Douglas." The description given by Hooker more nearly fits the plant illustrated. It would seem that the description was drawn from fresh material as was the illustration, and that an error was made in the source of the seed that gave rise to the plant. The description and the illustration of Hooker fit *Ipomopsis inconspicua* Smith, whatever that species may be.

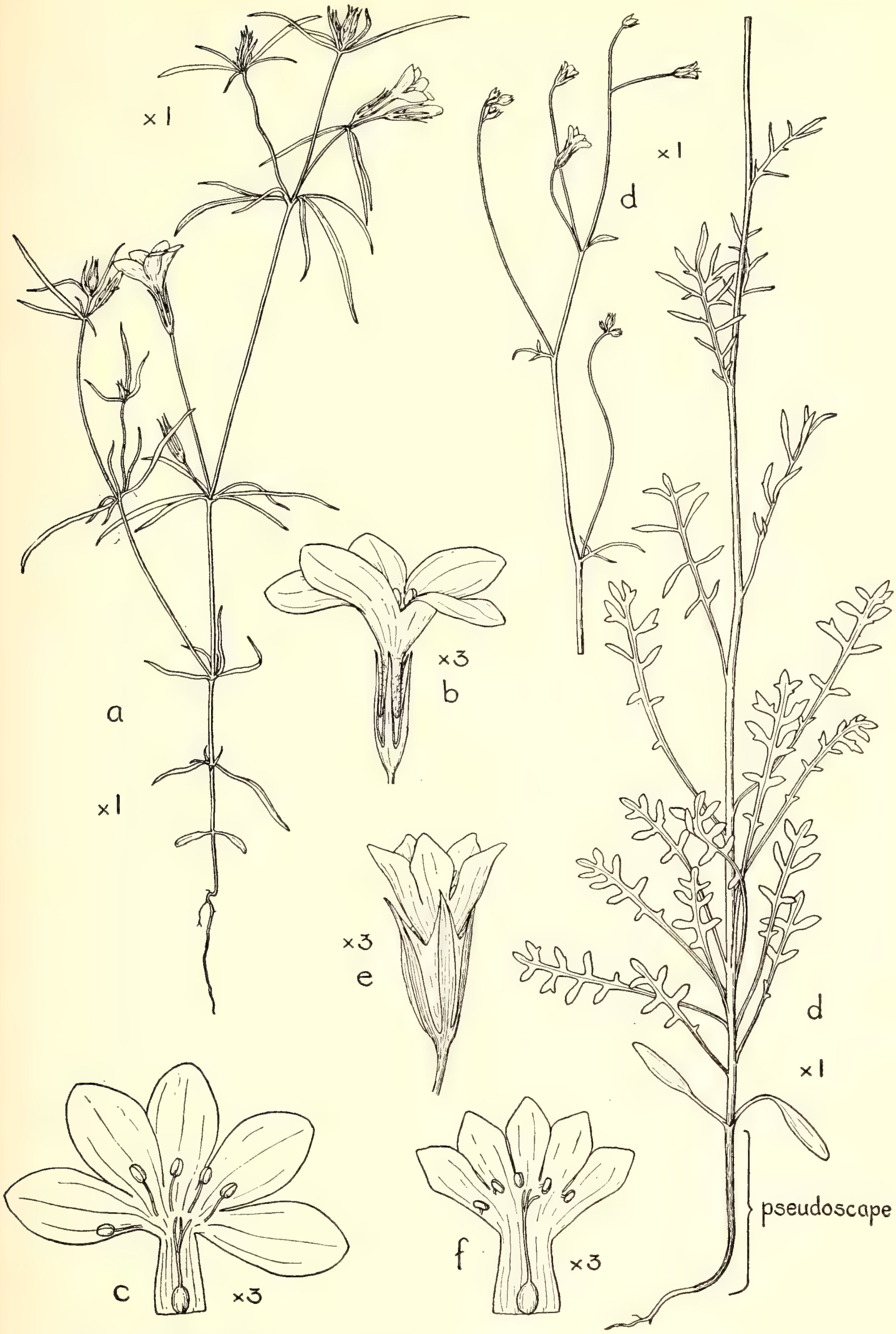

PLATE 26. LINANTHUS WIGGINSII AND GILIA CLOKEYI. Figs. a–c, *Linanthus Wigginsii;* figs. d–f, *Gilia Clokeyi.*

Later botanists have largely gauged their concept of *Gilia inconspicua* on the specimen of Douglas rather than on the description and illustration of either Smith or Hooker. As a result, the name *G. inconspicua* Dougl. ex Hook. is erroneously applied to the plant of the arid interior of the Great Basin of North America. Smith's plant was grown in England and described before any botanist had traversed that portion of the interior of America. The next oldest available name for this group of plants is *Gilia sinuata* Dougl. ex Benth. based on specimens collected by Douglas from near the confluence of the Okanogan River with the Columbia. This entity has been regarded by different authors as distinct either specifically or varietally from *G. inconspicua* Dougl. ex Hook. or as completely synonymous with that species. At any rate the plants represented by these names constitute an exceedingly variable genetic complex, and an eco-genetic analysis must be made before a clear understanding of the taxonomy of the group is possible.

The identity of the plants represented by the name *Ipomopsis inconspicua* Smith is not easy to determine. It seems probable that if they were derived from western North America they must have come from the coastal region. In North America plants of the group now passing under the name *Gilia multicaulis* Benth. are an excellent match for the illustrations of Smith and Hooker and could well have been collected at Monterey, San Francisco or Bodega, points visited by most of the early exploring expeditions. In both illustrations mentioned above, only portions of the plants are represented and these are not sufficiently complete to make identification certain. On the other hand, *Gilia laciniata* Benth. and *G. valdiviensis* Griseb. of South America are also close. Because of the permanent uncertainty as to the identity of Smith's original material the name *Gilia inconspicua* should be designated as a *nomen confusum.*

Gilia Clokeyi sp. nov. Herba annua erecta, 5–30 cm. alta, plerumque pseudoscapo evidente, 15–25 mm. alto; caules infra plerumque simplices in inflorescentibus ramosi; cotyledones lineari-spatulati, 12–16 mm. longi, 2–2.5 mm. lati, in petiolos graciles attenuati; folia in ambitu anguste oblonga, alterna, basi non rosulata in inflorescentibus abrupte reducta bracteata, pinnate vel bipinnate lobata, lobis aliquanto remotis, foliorum inferiorum segmentis ultimis ovatis, superiorum lanceolatis, glabra vel rarius sparse floccosa tandem glabrescentia, textura delicata; pedicelli atque ramuli florales ultimi glandulis paucis nigris capitellatis; calyx infra sinus membranaceus, membranis aliquanto distensis; corolla infundibuliformis, 6–9 mm. longa, pallido-coerulea vel fere alba, faucibus luteis, 1–1.5 mm. longis, tubo luteo, intus glabro, 3 mm. longo, lobis rhomboideis, circa 3 mm. longis; stamina in sinubus corollae affixa, antheris subsessilibus, circa 0.6 mm. longis, albis vel pallido-coeruleis, polline antheris similiter tincto;

pistillum 3–9 mm. altum, stylo apice diviso, ramis 0.5–1 mm. longis; capsula late ovoidea; semina matura non visa.

Erect annual 5–30 cm. high, usually with an evident pseudoscape 15–25 mm. high; stems usually simple below, openly branched in the inflorescence; cotyledons linear spatulate, 12–16 mm. long, 2–2.5 mm. wide, the lower one-third or one-half narrowed to a slender petiole; leaves narrowly oblong in outline, alternate, not in a basal rosette, becoming abruptly reduced and bracteate in the inflorescence, pinnately, or sometimes bipinnately lobed, the lobes somewhat remote, the ultimate segments of the lower leaves ovate, those of the upper lanceolate, glabrous, or more rarely sparingly floccose and becoming glabrate, texture thin and delicate; pedicels and ultimate branches of the inflorescence with a few black tack-shaped glands; calyx membranous below the sinuses, the membrane somewhat distended; corolla funnelform, 6–9 mm. long, pale blue to almost white, lobes rhomboid about 3 mm. long, throat and tube yellow, throat 1–1.5 mm. long, the tube 3 mm. long, glabrous within; stamens inserted in the sinuses of the corolla lobes, anthers subsessile about 0.6 mm. long, white to pale blue, pollen of the same color; pistil 3–9 mm. high, style divided at the tip, the three branches 0.5–1 mm. long; capsule broadly ovoid, mature seed not seen.

Type. Larrea belt, altitude 1200 meters, north base of limestone ledge, Red Rocks, Charleston Mountains, Clark County, Nevada, March 31, 1940, *I. W. Clokey 8599* (Clokey Herbarium at the Herbarium of the University of California). Other collections. Talus slopes above Wilson's Ranch, Charleston Mountains, Clark County, Nevada, May 3, 1939, *Bassett Maguire 16620*.

Gilia Clokeyi has been passing with a complex group of plants as *Gilia inconspicua* (Smith) Dougl., a name which, as has been indicated above, is of uncertain identity. The newly recognized entity may be distinguished readily by the lack of a rosette of congested leaves at the base of the stem, also by the essentially glabrous herbage, remotely lobed leaf blades and long narrow cotyledons.

Linanthus Wigginsii sp. nov. Herba annua, 3–12 cm. alta simplex vel pauciramosa; internodia 5–50 mm. longa, pilis densis sparsisve, debilibus brevibus contortis, tandem glabrescentibus; cotyledones lineari-spatulati, 3–5 mm. longi; folia infra saltem opposita aliquando in inflorescentibus subopposita vel alterna, palmatim in 3 (2–5) segmentis linearibus 5–20 mm. longis incisa, vel inferiora et superiora quandoque simplicia; flores non congesti, solitarii vel gemini in axillis foliorum superiorum; pedicelli graciles inaequales, 3–20 mm. longi; calyx 4–5 mm. longus, tubo 1 mm. longo, lobis linearibus 4 mm. longis, marginibus inferioribus ad sinus calloso-incrassatis infra sinus membranis parvis; corolla late infundibuliformis alba, longitudine rare 10 mm. excedens, tubo calycem aequante, vel subaequante, extus pubescente intus glabro, faucibus abrupte expansis 1.5–2 mm. longis, lobis

obovatis 5 mm. longis, 2–3.5 mm. latis; stamina faucium in parte inferiora affixa, filamentis filiformibus glabris, 1.5 mm. longis, antheris luteis, 0.5 mm. longis e faucibus exsertis; ovarium 1 mm. altum, stylo 3–5 mm. longo ad medium in tres divisionibus linearibus inciso; fructus non visus; semina non visa.

Slender annual 3–12 cm. high, simple or with a few branches; internodes 5–50 mm. long with dense or sparse, weak short twisted hairs, becoming glabrate; cotyledons linear-spatulate, 3–5 mm. long; leaves opposite at least below, sometimes subopposite or alternate in the inflorescence, palmately cleft into 2 to 5 (normally 3) linear divisions, 5–20 mm. long, occasionally the lower and sometimes the upper simple; flowers solitary or in pairs in the upper leaf axils on slender unequal pedicels, showing little tendency toward congestion; pedicels 3–20 mm. long; calyx 4–5 mm. long, the tube 1 mm. long, the linear lobes 4 mm. long, lower margins of the lobes callous thickened toward and in the sinus, the sinus with a small membrane; corolla broadly funnelform, white, rarely exceeding 10 mm. in length, the tube equal or subequal to the calyx, pubescent externally, glabrous within; throat abruptly expanded, 1.5–2 mm. long, lobes obovate, 5 mm. long, 2–3.5 mm. wide; stamens inserted on the lower half of the throat, filaments threadlike, glabrous, 1.5 mm. long, anthers 0.5 mm. long, yellow, exserted from the throat; ovary 1 mm. high, style 3–5 mm. long, cleft to almost one-half its length into three linear divisions; fruit and seeds not seen.

Type. Southern end of Santa Maria plains, Baja California, Mexico, February 5, 1935, *Ira L. Wiggins 7557* (Dudley Herbarium, Stanford University, 263704; isotype, Herbarium of the University of California, 659206).

Linanthus Wigginsii is closely related to *L. Nuttallii* var. *floribundus* (Greene) McMinn from which it differs, however, in a number of significant characters. These differences may be best expressed by a key:

Plants perennial from a woody base, 1–5 dm. high; internodes stout; leaves 5 to 8 cleft, rarely subopposite; many-flowered, flowers sessile or short-pedicelled; calyx pubescent; corolla 12–20 mm. long, lobes 7–10 mm. long, spatulate to ovate; stamens included, filaments 1 mm. long, anthers 0.75 mm. long . . . . *L. Nuttallii* var. *floribundus*

Plants slender annuals, 3–12 cm. high; internodes slender; leaves 2 to 5 cleft, usually subopposite in the inflorescence; few-flowered; flowers short-pedicelled to long-pedicelled; calyx glabrous; corolla 8–10 mm. long, lobes 5 mm. long, obovate; stamens exserted, filaments 1.5 mm. long, anthers 0.5 mm. long . . . . *L. Wigginsii*

Linanthus Wigginsii seems definitely to establish a place for *L. Nuttallii* (Gray) Greene and its allies in the genus *Linanthus* rather than in the genus *Leptodactylon* where it has been placed by some authors. Its position in this latter genus has been maintained solely upon its perennial woody habit. The relationship

between *L. Nuttallii* and *L. Wigginsii* is so close as to make generic separation impossible. Similarity between the two species may be noted in a tendency of the flowers to occur in pairs in the leaf axils, in the unequal pedicels of the paired flowers, in the shape, color and pubescence of the corolla, and in the very similar details of the calyx such as the thickening of the margins of the lobe and the nature of the membrane in the sinuses.

Department of Botany,
University of California, Berkeley,
February, 1942.

EBUROPHYTON HELLER: A VALID GENUS OF THE ORCHIDACEAE

Louis O. Williams

Eburophyton Austinae (Gray) Heller, Muhlenbergia 1: 49. 1904. *Chloraea Austinae* Gray, Proc. Am. Acad. 12: 83. 1876. *Cephalanthera oregana* Reichb. f., Linnaea 41: 53. 1876. *Cephalanthera Austinae* Heller, Cat. N. Am. Pl. ed. 2, p. 4. 1900. *Serapias Austinae* A. A. Eaton, Proc. Biol. Soc. Wash. 21: 66. 1908.

In 1876 Asa Gray described an orchid from California which he called *Chloraea Austinae*. *Chloraea* is a genus of orchids occurring in South America from the Falkland Islands north to Peru, with its greatest concentration of species in the Andes of Chile. *Chloraea* occurs mainly in open habitats and quite often in very hard, sterile soil. So far as I know no member of the genus is saprophytic. In the same year, 1876, H. G. Reichenbach described the same species, from a specimen collected by Nuttall, under the name of *Cephalanthera oregana*. *Cephalanthera* is a genus primarily of Europe and adjacent regions but one in which the species are not saprophytic. The third generic name was that applied by Heller in 1904, *Eburophyton,* a name designed to contain the single species in question. In 1908 A. A. Eaton placed the species in still a fourth genus as *Serapias Austinae*. Although the species has no special character to recommend its being placed in this genus it is here that it has been treated most often. Ames in "Enumeration of the Orchids of the United States and Canada" (1924), the most authoritative work yet published on the region covered, placed the species here.

Eburophyton Austinae is at once excluded from *Serapias* by its anther which is attached by a slender filament and is not solidly attached as in *Serapias*. From *Chloraea* it is distinguished by its saprophytic habit, by the lip being divided into an epichile and hypochile, with the hypochile gibbous at the base. From *Cephalanthera* the distinction is more difficult but the scarious nature of the leaves, saprophytic habit and geographical distribution would seem to indicate a separate genus.

Botanical Museum, Harvard University,
Cambridge, Massachusetts,

REVIEW

Standardized Plant Names. By Harlan P. Kelsey and William A. Dayton, prepared for the American Joint Committee on Horticultural Nomenclature. Second edition. Pp. xvi + 675. J. Horace McFarland Company, Harrisburg, Pennsylvania. 1942. $10.50.

As announced in the preface to the second edition "the purpose of 'Standardized Plant Names' is to bring intelligent order out of the chaos in names of plants and plant products existing the world over." We learn from the preface that the authors believe that the confusion in plant nomenclature is due to mistakes in identification and labeling and to disagreement in opinion, practice and judgment among botanists; we learn also that the general basis of the work of the committee appointed to bring "intelligent order" out of this chaos is "to agree arbitrarily upon some one name for each plant, by which name it can be designated for a definite term of years"; we learn to our chagrin that "a right label on the wrong plant or plant product may cause even more loss or disaster than the wrong label on the right plant or plant product" (page viii).

Throughout the preface there are presented certain rules whereby, as implied in the title, the names of plants are to be standardized. Although these rules are not definitely organized into a precise code of nomenclature, with a little patience one can collect and arrange them. The authors are aware of the rules adopted by the International Conference in London in 1930 but some of the rules promulgated by this conference from the standpoint of the present authors are inadmissable. They therefore accept what they like of these rules and reject what they do not like. Botanists have had similar experiences in bringing "intelligent order" out of chaos and were hampered by a similar group working from a nationalistic point of view, which if we mistake not, stemmed from the same habitat as this effort. It seems to the reviewer that since plants and plant products are a considerable item in international trade, their nomenclature is at once placed upon an international basis. Therefore, any attempt to standardize these names should result from international cooperation. This it would seem, is the intelligent basis for procedure and by not accepting it the authors violate the first point of their purpose.

It should be pointed out that the authors do not state specifically that their object is to develop a code of nomenclature but rather to "agree arbitrarily upon some one name for each plant." However, to standardize names implies that you have standards whereby this is to be accomplished. Moreover, if the rules mentioned in the preface are not to be used as a guide, why are they published in conjunction with plant names under a title that implies a code of standardization? The reader must assume that

the authors intended that these rules should serve as a code or basis for the standardization of the nomenclature developed.

Several of the rules apply only to scientific names which are under the jurisdiction of the International Committee on Botanical Nomenclature and hence are not the concern of this or any other committee on horticultural names. Since horticultural interests are represented on the International Committee any use of scientific names at variance with the International Rules is unjustified and serves only to create confusion. Although it is always in order to recommend new rules to clarify plant nomenclature it is never in order for a small group to reject rules adopted through international cooperation.

These rules cannot correct mistakes in identification nor can they prevent disagreement in opinion, practice and judgment among botanists; these being the principal causes of confusion in the opinion of the authors. Rules of nomenclature should be aimed solely at matters which cause confusion in the names of plants. The consolidation of compound names adopted by the committee serves no useful purpose and more often than not, causes a name to violate the international code rule involving pronunciation and excessively long words. For example, try to pronounce "Gianthyssop", "Pussyears", "Sevenyearapple", "Globeamaranth", and "Holyghostflower." Consider "Browneye Babyblue-eyes Nemophila." We are not joking, this is the name the authors propose for *Nemophila atomaria* var. *discoidalis* (page 397). This rule as construed and practiced by these authors in many instances places the problem of the naming of plants upon a plane of ridiculousness never before achieved. We again call your attention to "Gianthyssop." To what language does it belong? It certainly is not English. These and hundreds of other proposed common names are a combination of good English words that by compounding have been translated into an atrocious form of pigeon English. When you write it, "Browneye Babyblue-eyes Nemophila" gets under the three-word limit by its beautiful eyelashes, but don't try to pronounce it as three words. After accepting certain rules the authors do not hesitate to practice methods of circumventing them. Although opposing the capitalization of specific and varietal names in the scientific nomenclature of plants, it is of interest to note that for common names no such concern is felt. Every word of a name is capitalized and in compounding words the capital letter is retained. Thus we find orthographical monstrosities such as "RockyMountain", "SanDiego", "EastIndies" and "SantaRosaIsland."

With respect to the application of the principle of priority to horticultural names certain difficulties need to be considered. Priority is a sound principle upon which to establish a stable nomenclature. It demands, however, that every name be documented with authority so that its position in the priority sequence

can be established. Some of the names in this work that have been presented by societies such as the American Carnation Society and the Chrysanthemum Society are documented at least to originator but even in these the date is sometimes omitted. Unless there is maintained a specimen voucher or an adequate illustration we believe that it will be impossible at some future date to check against errors in identification and the misuse of names. The majority of the names used in the work give no evidence of supplying any basis whereby priority may be established if one should choose to apply it. To put horticultural names in a position to be standardized would require a major revolution in the practices of horticulturists with respect to giving and documenting the names of their plants. A system could be worked out by a qualified international committee for documenting names already in use and rules might be set up to which, in the future, authors would be required to conform. We are not concerned in nomenclature with the allocation of credit or honor for discovery or horticultural selection, we are concerned with responsibility for applying the correct name to a plant.

There are many more points that might be discussed in connection with this work and there is much that deserves credit. The chief criticism to be leveled against it is that the committee conceived of its problem as being one of giving plants names rather than one of proposing methods whereby the horticulturist could adjust his practices in naming plants so that standardization would be possible and nomenclature could be stabilized in as simple and dignified a manner as possible.—Herbert L. Mason, Department of Botany, University of California, Berkeley, California.

PROCEEDINGS OF THE CALIFORNIA BOTANICAL SOCIETY

January 22, 1942. Meeting, 103 Wheeler Hall, University of California, Berkeley, at 7:45 P.M. The retiring president, Professor E. B. Babcock, opened the meeting. Dr. Mildred E. Mathias requested, with regret, that the nominating committee withdraw her name from the list of nominations for 1942. The name of C. R. Quick was substituted by due process for nomination to the secretaryship. The following new officers were installed: Dr. Alva R. Davis, President; Dr. Palmer Stockwell, First Vice-President; Dr. Reed C. Rollins, Second Vice-President; Mr. Clarence R. Quick, Secretary; Dr. William M. Heisey, Treasurer. Dr. Davis, incoming president, introduced Dr. Reed C. Rollins, Instructor in Botany, Stanford University, who presented an interesting illustrated lecture on "The geographical distribution, speciation, and natural variation in Arabis and other Cruciferae."

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A WEST AMERICAN JOURNAL OF BOTANY

Contents

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THE SIGNIFICANCE OF CERTAIN PLANT NAMES

Carl Sumner Knopf

Botanical terminology is filled with oddities. An ancient Roman would probably find much amusement in the atrocious Latinesque mongrels, denoting that Smith, Ph.D., found and classified the Something-or-other Smithii. However, in many common and technical designations there is hidden a veritable romance of linguistic adventure, where research leads across seas and sands to natural habitats and original appellations.

In giving derivation of English words and common scientific terms, dictionaries often stop with Latin or Greek forms. Occasionally, reference will be made to Arabic. Yet many Graeco-Latin words were dialectic modifications of borrowed Near Eastern terms which were names of articles of trade peddled by Aramean and Phoenician merchants.

The family, Boraginaceae, has generally been identified with the Mediterranean littoral and eastward. Littre (Dictionnaire de la Langue Francaise), speaks of it as a "Plante Sudorifique, originaire d'Afrique et introduite par les Maures en Espagne." It was long known for cardial and febrifuge properties. Gerarde (1597) noted that borage was used in salads "to make the mind glad." Britain's famed "cool tankard" combined the leaves with wine, water, lemon and sugar. Great healing power was accredited to borage. The roots yielded brown and purple dye.

If this plant or some special use of it was introduced into Spain by the Moors, an oriental ancestry of its name would be logical. The scattered variant forms are easily recognizable, as German *boretsch,* French *bourranche,* Italian *borraggine,* Spanish *borraja,* Latin *borego,* and in all probability, Greek *pourakion.* Some have tried to connect the term with Latin *burra,* "a hairy cloth," or French *bourre,* "animal hair," since the group is notably hirsute.

Among the Arabs the plant is known as *barwaq.* Boiled with olive oil and vinegar it is a specific for jaundice. The root juice is used for skin eruptions; the juice of the leaves sometimes mixed with food "to cause excitement." In Zerolo's "Diccionario Enciclopedico de la Lengua Castellana," the Spanish *borrachuela* is described as causing "cierta perturbacion." Both Arab and Spaniard note the mild intoxication. Their terms are philologically related, the Arabic *q* passing over into Spanish *ch* and *j, borraja* and *bourrachuela,* French *bourrache.*

Linguists long pondered over the origin of the Spanish term *borracho,* "drunk." Obviously it follows the same consonantal root pattern, *b-r-g/j/q/ch* always connected with some kind of exciting, mind-confusing state and a plant juice inducing it. An

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Arabic word, *baraq,* means "to be confused," "weak," or "with eyelids immovable." A noun, built on the same root structure, *barqat,* means a "fit of confusion" or "blind perplexity." In Spanish, confusion of judgment is *borrachez.* Since Arabic *q* is formed back of the palate, it passes easily into Spanish *ch,* while the dental *t* as readily becomes a voiced sibilant, *z.*

Following the same intoxication motif, an Arabic wine basin is called an *ibriq,* and the Spanish leather wine bottle is a *borracha.* Again the familiar b-r-g/q/ch of borage is clear. In spring, every vivid patch of fiddleneck (the *Amsinckia intermedia* of Oregon and *A. Douglasiana* of California) or heliotrope, or forget-me-not (*Myosotis*) can give the scholarly observer the mild intoxication of adventure—to Merrie England and old borage remedies; to France and her "plante sudorifique"; to Moorish Spain and convivial *borrachos;* to Arabia concocting jaundice medicine; to Italy where Roman tongues twisted a foreign term from the eastern provinces, while in Greece, Hellenic tongues did the same. The mucilaginous, sudorific, emollient, cooling, stimulating, hirsute borage carries a story in its name.

Cotton is equally revealing. The Arab long ago knew *qutun.* If he affixed the definite article it was *al-qutun,* which became Spanish *algodon* and Portuguese *algadao.* Spanish cotton cloth became *coton.*

The ancient Greeks, still barbarians when the Phoenicians were civilized sophisticates, bought many a novelty from the Near East. The well-made *kitunah* became the most popular article of Greek clothing, the *xiton.*[1] The name probably came from a Semitic root, k-t-n, "to clothe." In Assyrian, a word *xatanu* meant "protect." *Xutenu* meant "protection" and, incidentally, sounded quite like the Greek *xiton* and Phoenician *kitunah.* An Assyro-Babylonian *xittu* was a "border," like the ruffles on a garment.

Through all the terms runs a basic idea—a garment; woven stuff; protection; clothing; fringe. The common throat sounds for the idea are a glottal stop, a dental, and a dental-nasal—*k/q/x/-t-n.* It became stabilized in Arabic *qutun,* and emerged in English as "cotton." Back of it was Phoenicio-Aramaic *kitunah;* and back of that, Assyro-Babylonian *xatanu* and *kitunnu.*

Speaking of cotton (of the family Malvaceae, genus *Gossypium*) reminds one that this family name, Latin *malva,* garbled into Anglo-Saxon *mealwe,* has also a distinct Near East connection. When the Greeks called mallow *malaxe,* they left a linguistic clue, pointing to some term that included an extra consonant, *x.* The Greek *malakos,* suggested "soft" and mallow has been used in medicine as an emollient. In the Greek words the extra sound of a guttural *xi* or *kappa* (k) is clear.

[1] *X* is used to denote the throaty, raspy, guttural, like a half-swallowed *k* or *q,* indicated by Greek *xi* and Semitic *xeth.*

Turning to Near East literature, one finds in the great book of Job (30: 4) the old man's plaint that everybody laughs at his suffering, and even the "salt-weed" or "mallow" cutters deride him. The Palestinian Negeb or south country is volcanic and saline. Spring torrents bring down mineral salts from the hills. Water holes turn salty and crystals often line the edges. Even the Babylonian texts refer to this salt country. The nomad population adapted its resources to their needs. Every edible or therapeutic plant had to yield its benefit.

When Job mentioned the mallow cutters he used the term *malluax.* The final consonant, *xeth,* had much the same guttural sound as Greek *xi.* References to the salt lands in Psalms (107: 34) and Jeremiah (17: 6) employed the same root. In Babylonia, a *malaku* was a sailor, one identified with salty waters. In passage from the cradle of civilization to and through the Mediterranean tongues, the glottal stop, *k,* or guttural *x,* could be easily lost, leaving the softer *malva, malba,* and *mallow.* But the presence of the extra consonant in some of the Greek terms provides the clue pointing to oriental habitat and initial use of the mallow.

The philological background of botanical nomenclature can not be expected to provide complete implementation for habitat and dispersion studies, but there are possible suggestions. Certainly the linguist can clasp hands with the botanist when he finds basic word patterns such as *b-r-g, k-t-n,* or *m-l-x* stretching from Persia to the Pacific.

Willamette University, Salem, Oregon,
January 12, 1942.

NOTES ON THE FLORA OF THE CHARLESTON MOUNTAINS, CLARK COUNTY, NEVADA. IV.[1] ASTRAGALUS

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For assistance in the study of the *Astragali* of the Charleston Mountains and for affording me the use of the Pomona College Herbarium, including the Marcus E. Jones Herbarium, I wish to express thanks to Dr. Philip A. Munz. Appreciation is also extended to the curators of the herbaria of the United States National Museum, the New York Botanical Garden and the University of California for the loan of type and critical specimens. I also wish to thank Mr. Rupert C. Barneby for information about Nevada *Astragali* and for the preparation of the accompanying plate.

[1] Previous notes in this series have appeared as follows: Madroño 4: 128–130. 1937; Bull. So. Calif. Acad. Sci. 37: 1–11. 1938, 38: 1–7. 1939.

Type specimens of species herein described as new are in the Clokey Herbarium now on deposit at the University of California, Berkeley.

Key to the Species of Astragalus

I. Perennials

1. Pods 1-celled

A. Pods sessile.
- Pods leathery.
  - Pods horizontal, 1.5 cm. or more long; low plants, stems decumbent.
    - Pods strigose, tapering at base, narrowly lanceolate-linear, decidedly arcuate, 3–4.5 cm. long.
      - Leaflets elliptic; pubescence appressed, hairs with median attachment; flowers 2–3 cm. long .... 1. *A. amphioxys*
      - Leaflets oval to broadly obovate; pubescence loose, somewhat tangled, hairs with terminal attachment .... 2. *A. Tidestromii*
    - Pods long villous, obliquely ovoid with upturned tips.
      - Corolla purple.
        - Pubescence of leaflets appressed; calyx tube about 10 mm. long, with nearly white hairs, teeth 2–3 mm. long; pods 1.5–2.5 cm. long .... 3. *A. Newberryi*
        - Pubescence of leaflets loosely villous; calyx tube 7–8 mm. long, with mostly black hairs, teeth 4–5 mm. long; pods 3 cm. or more long ..... 3a. *A. Newberryi* var. *funereus*
      - Corolla crimson .... 4. *A. coccineus*
  - Pods erect, about 1 cm. long; flowers 7–10 mm. long; stems slender, 3–5 dm. long ... 5. *A. humistratus* var. *sonorae*
- Pods membranous, much inflated, speckled; sutures equally convex; leaflets lance-linear to linear .... 6. *A. aequalis*

B. Pods stipitate.
- Pods leathery; stipe from very short to nearly as long as calyx .... 7. *A. Preusii*
- Pods membranous, much inflated, mottled ...... 8. *A. artipes*

2. Pods completely or incompletely 2-celled

A. Pods partially 2-celled; septum narrow.
- Pods stipitate, somewhat inflated.
  - Stipe 3–5 mm. long.
    - Pods leathery, erect, nearly straight; flowers white with purple tips, about 13 mm. long .... 9. *A. arrectus* var. *remotus*
    - Pods membranous, mottled, strongly arcuate; flowers purple, 18–20 mm. long ... 10. *A. Beckwithii* var. *purpureus*
  - Stipe very short; pods leathery, filled with pulp when green .... 11. *A. praelongus*
- Pods sessile, leathery, slightly arcuate; flowers purplish, 8–10 mm. long .... 12. *A. mohavensis*

B. Pods completely 2-celled or with the septum reaching almost to ventral suture, sessile.
  Pods papery, much inflated.
    Flowers white with purple tips; caespitose perennials, stems less than 1 dm. long; pods mottled, septum formed by protrusions from both sutures; alpine or subalpine.
      Pods 2–3 cm. long, acuminate ellipsoid .... 13. *A. platytropis*
      Pods about 1 cm. long, oval, with a slender beak 1–2 mm. long .... 14. *A. kernensis* subsp. *charlestonensis*
    Flowers purple; stems erect, more than 3 dm. high; pods about 2 cm. long, rounded ovoid, septum formed by protrusion from dorsal suture only; Larrea or lower Juniper Belt .... 15. *A. lentiginosus* var. *Fremontii*
  Pods coriaceous, not inflated.
    Plants 1–4 dm. high.
      Pods nearly straight.
        Pods white shaggy-woolly, 2–2.5 cm. long; flowers white with purple tips, 13–15 mm. long .... 16. *A. Minthorniae*
        Pods glabrous, 2.5–3 cm. long; flowers purple tinged, 7–8 mm. long .... 17. *A. bernardinus*
      Pods strongly arcuate and strongly reticulate, white strigose; flowers purple, 6–8 mm. long .... 18. *A. hemigyrus*
    Plants acaulescent or subacaulescent, less than 1 dm. high.
      Leaflets 3–7, oblanceolate to obovate; calyx teeth 3–4 mm. long .... 19. *A. calycosus*
      Leaflets 5–13, elliptic-oblanceolate; calyx teeth 1–1.5 mm. long .... 20. *A. mancus*

II. Weak, decumbent annuals; flowers 3–5 mm. long, white or purple; pods sessile

Racemes few-flowered; pods papery, linear, 1.5–2 cm. long.
  Pods 2-celled except towards tip.
    Keel with a short, rounded porrect beak .... 21. *A. Nuttallianus* var. *trichocarpus*
    Keel with an acuminate, porrect beak .... 21a. *A. Nuttallianus* var. *acutirostris*
  Pods 1-celled, septum from dorsal suture, if present, a mere line .... 21b. *A. Nuttallianus* var. *imperfectus*
Racemes dense and headlike; pods 2-celled, coriaceous, cross-wrinkled, obliquely ovoid, 3–4 mm. long .... 22. *A. dispermus*

1. Astragalus amphioxys Gray, Proc. Am. Acad. 13: 366. 1878. *Xylophacos amphioxys* Rydb. Bull. Torr. Bot. Club 32: 662. 1906.

Texas to southern Nevada, Arizona and northern Chihuahua. Local habitat, occasional in Larrea Belt at about 1000 meters: Cottonwood Springs, *Clokey 8496;* Wilson's ranch, *Maguire 18035.* Blooms in April.

2. **Astragalus Tidestromii** (Rydb.), comb. nov. *Xylophacos melanocalyx* Rydb. Bull. Torr. Bot. Club 52: 149. 1925; not *Astragalus melanocalyx* Boiss. Nouv. Mem. Soc. Nat. Hist. Mosc. 12: 59. 1860. *Xylophacos Tidestromii* Rydb. Bull. Torr. Bot. Club 52: 155. 1925. *Astragalus Marcusjonesii* Munz, Leafl. West. Bot. 3: 50. 1941.

Southwestern Utah, southern Nevada, northwestern Arizona and southeastern California. Local habitat, gravelly, brushy soil in Larrea and lower Juniper belts at elevations of 1100 to 1300 meters: Kyle Canyon, in flower, April 26, 1937, *Clokey 7564;* in fruit, May 20, 1937, *Clokey 7563;* Kyle Canyon Fan, *Clokey 7995,* in fruit, May 15, 1936, *Clokey 8220;* Las Vegas to Red Rocks, in flower and fruit, March 31, 1940, *Clokey 8596;* Wilson's ranch, in fruit, May 27, 1919, *Tidestrom 9661* (type of *Xylophacos Tidestromii*).

Astragalus Tidestromii is abundant at a station 3 to 4 miles from Wilson's ranch, the type locality of *A. Tidestromii,* at the same elevation and in a similar environment. Studies in the field and herbarium show that there is considerable variation in the pubescence and in the pods. On the leaflets the pubescence varies from parallel and appressed to kinky and tangled. The hairs are always attached at the end and not in the middle as in *A. amphioxys.* The hairs on the calyx may be white, or white and black mixed. The pods vary from 3 to 4.5 centimeters in length and may be curved from a small arc to over half a semicircle. The seeds are reticulate, speckled with purple, 3.5 to 4 millimeters long by 2 to 2.5 millimeters wide. Both *A. melanocalyx* and *A. Tidestromii* were described originally from limited material. Our material has been compared with isotype specimens of *A. melanocalyx* and the type of *A. Tidestromii.* It is evident that these do not warrant even varietal distinction.

3. Astragalus Newberryi Gray, Proc. Am. Acad. 12: 55. 1876. *Xylophacos Newberryi* Rydb. Bull. Torr. Bot. Club 32: 662. 1906.

Utah and central Nevada south to western New Mexico, Arizona and extreme eastern California. Local habitat, scattered as single plants or small groups in openings on brushy ground in upper Larrea, Juniper and lower Pinyon belts: Clark Canyon, *Clokey 7168;* Charleston Park, *Clokey 7169;* Harris Springs road, *Clokey 7570;* Kyle Canyon, *Clokey 7569, 8404, 8405;* Kyle Canyon Ranger Station, *Train 2169;* Kyle Canyon to Deer Creek, *Clokey 7571;* Lee Canyon, *Clokey 7171;* Trout Creek, *Clokey 7170;* below Wheeler Wells, *Clokey 7167.* Blooms about May 1.

3a. Astragalus Newberryi Gray var. **funereus** (Jones) comb. nov. *A. funereus* Jones, Contr. W. Bot. 12: 11. 1908. *Xylophacos funereus* Rydb. Bull. Torr. Bot. Club 52: 367. 1925. *Astragalus Purshii* Dougl. var. *funereus* Jepson, Fl. Calif. 2: 360. 1936.

Southern Nevada and southeastern California. Local habitat, scattered and rare; openings on gravelly soil in the upper Larrea to the lower Yellow Pine belts: Kyle Canyon, *Clokey 7568;* Kyle Canyon trailer camp, *Train 1677*. Blooms about May 1.

A close relationship to *A. Newberryi* is evident from a study of the pods, and the larger size of both the flowers and pods warrants varietal standing. The pubescence of the calyx consists of both white and black hairs with either predominating.

4. Astragalus coccineus (Parry) Brandg. Zoe 2: 72. 1891. *A. Purshii* Dougl. var. *coccineus* Parry, West. Am. Sci. 7: 10. 1890. *Xylophacos coccineus* Heller, Muhl. 2: 217. 1906.

Colorado and Mohave deserts of California; reported from the Charleston Mountains by Jepson (Fl. Calif. 359. 1936). Should be looked for on lower foothills especially on the western side of the range. Blooms in April and May.

5. Astragalus humistratus Gray var. sonorae (Gray) Jones, Contr. W. Bot. 10: 58. 1902. *A. Sonorae* Gray, Pl. Wright. 2: 44. 1853. *Batiophaca Sonorae* Rydb. N. Am. Fl. 24: 317. 1929.

New Mexico, southern Nevada, Arizona and Sonora, Mexico. Very local in the Charleston Mountains: ridge above Charleston Park at an elevation of 2330 meters, associated with *Pinus scopulorum, P. monophylla* and *Juniperus scopulorum, Clokey 8408.*

The vegetative parts of specimens from the Charleston Mountains are near the lower limits in measurements. Blooms in June.

6. **Astragalus aequalis** sp. nov. Herba perennis erecta, e basi ramosa, 3–7 dm. alta; caules striati strigosi; folia 6–12 cm. longa; stipulae liberae anguste triangulares, 2–3 mm. longae; foliola 9–15 (plerumque 11) anguste lineari-lanceolata vel linearia obtusa utrinque strigosa, 12–40 mm. longa, 2–4 mm. lata; racemi axillares, folia subtendentia excedentes; flores 6–12, 10 mm. longi, lutei; calyx strigosus, pilis albis vel nigris, tuba 4–4.5 mm. longa, dentibus subulatis vel anguste triangularibus, 1–1.5 mm. longis; vexillum obovatum, apice emarginata, 12 mm. longum, 9 mm. latum; alae quam vexillo paullo breviores, lamina oblonga, 6 mm. longa, auriculo rotundo, 1 mm. longo; carina alis aequans, lamina 5–6 mm. longa, auriculo basalari brevi instructa; legumen sessile persistens chartaceum multo inflatum uniloculatum ellipticum, 3.5–4 cm. longum, 2 cm. latum, 1–2 cm. diametro, suturis subaequaliter convexis, sutura ventrali sulcata (ca. 1 mm.), albopubescens stramineum purpureo-maculatum vel purpurascens stramineo-maculatum; semina fusca, 2.5–3 mm. longa, 2 mm. lata.

Perennial, erect, branched from base, 3–7 dm. high; stems striate, strigose; leaves 6–12 cm. long; stipules free, narrowly triangular, 2–3 mm. long; leaflets 9–15 (usually 11), narrowly lance-linear to linear, obtuse, strigose on both sides, 12–40 mm. long, 2–4 mm. wide; racemes axillary, 6–12 flowered, extending

above the subtending leaves; flowers 10 mm. long, yellow; calyx tube 4–4.5 mm. long; teeth subulate to narrowly triangular, one-fourth to one-third the length of the tube, strigose with white or black hairs; banner obovate, slightly notched, 12 by 9 mm.; wings slightly shorter, blade oblong, 6 mm. long, with a rounded auricle 1 mm. long; keel as long as the wings, blade 5–6 mm. long, with a short, rounded, basal auricle; pods sessile, persistent, papery, much inflated, 1-celled, 3.5–4 cm. long, elliptical, cross-section elliptical, 2 cm. wide, 1 cm. deep to rounded, 1.5 cm. in diameter, sutures nearly equally convex, ventral suture sulcate about 1 mm., white-pubescent, straw colored speckled with purple to purplish speckled with straw color; seeds smooth, brown, 2.5–3 mm. long, 2 mm. wide.

Occurs at scattered locations in the Charleston Mountains, Clark County, Nevada: Harris Springs road, associated with *Juniperus utahensis,* elevation 1900 meters, in fruit, June 4, 1937, *Clokey 7572* (type); Kyle Canyon, with *Pinus scopulorum,* elevation 2180 meters, in flower, May 10, 1936, *Clokey 7172;* elevation 2270 meters, in fruit, July 2, 1936, *Clokey 7173;* Lee Canyon, elevation 2450 meters, June 16, 1939, *Alexander 791;* ridge north of lower Lee Canyon, elevation 2000 meters, in fruit, June 6, 1936, *Clokey 7174;* Willow Creek at 1810 meters, in fruit, June 15, 1937, *Train 1997.*

Astragalus aequalis is most closely related to *A. Douglasii* (T. & G.) Gray and *A. Douglasii* var. *Parishii* (Gray) Jones. The three can be distinguished as follows:

Pods attached to a minute boss, falling free from the calyx, dorsal suture much more convex than the nearly straight ventral suture.
  Stipules 4 mm. long; leaflets 15–23, elliptic to oblong; calyx tube 3 mm. long; teeth subulate, at least half as long as the tube. West central California, coastal. . . . . *A. Douglasii*
  Stipules 4–5 mm. long; leaflets 11–25, oblong to elliptic-obovate; calyx tube 4 mm. long; teeth deltoid, one fourth to one third as long as the tube. Southern California, west of the deserts . . . . *A. Douglasii* var. *Parishii*

Pods not attached to a minute boss, falling with the calyx, ventral and dorsal sutures equally convex; stipules about 2 mm. long; leaflets 9–15 (usually 11), narrowly lance-linear to linear, 12–40 mm. long, 2–4 mm. wide; calyx tube 4–4.5 mm. long; teeth subulate, one fourth to one third as long as the tube. Charleston Mountains, Nevada . . . . *A. aequalis*

7. ASTRAGALUS PREUSSII Gray, Proc. Am. Acad. 6: 222. 1864. *Phaca Preussii* Rydb. Bull. Torr. Bot. Club 40: 47. 1913.

Central Utah, central Arizona, southern Nevada to southeastern California. Local habitat, sandy or gravelly calcareous soil in the Larrea Belt below 1200 meters: Cottonwood Springs ranch, *Clokey 8460;* Indian Springs, *Clokey 8406.* Blooms in April.

8. ASTRAGALUS ARTIPES Gray, Proc. Am. Acad. 13: 370. 1878. *Phaca artipes* Rydb. Bull. Torr. Bot. Club 32: 664. 1906.

Colorado to Nevada and Arizona. Local habitat, with *Pinus scopulorum* at an elevation of about 2700 meters: Lee Canyon, July 11, 1938, *Train 2141*.

9. ASTRAGALUS ARRECTUS Gray var. REMOTUS Jones, Rev. Astrag. 162. 1923. *Tium remotum* Rydb. N. Am. Fl. 24: 391. 1929.

From La Madre Mountain to Good Springs, Clark County, Nevada. Local habitat, among limestone and sandstone rocks at elevations from 1100 to 1700 meters: Cottonwood Springs, *Clokey 8407;* Excelsior Canyon, *Clokey 8713;* Mountain Springs, *Clokey 7998;* Rocky Gap Springs, *Clokey 8714;* Wilson's ranch, *Maguire 18041, 18067*. Blooms in April or May.

10. ASTRAGALUS BECKWITHII Torr. & Gray var. PURPUREUS Jones, Zoe 3: 288. 1893. *Phaca artemisiarum* Rydb. Bull. Torr. Bot. Club 40: 48. 1913. *Phaceomene artemisiarum* Rydb. N. Am. Fl. 24: 383. 1929.

Western Utah, eastern and southern Nevada. Local habitat, widely scattered in dry soil in upper Larrea, Juniper and Pinyon belts at elevations from 1800 to 2450 meters: Charleston Park, *Alexander 590;* Clark Canyon, *Clokey & Anderson 7164, 7165;* Cold Creek, *Clokey 7989, Train 1976;* Cold Creek Spring, *Clokey 7565;* Deer Creek road, *Clokey 7566;* Harris Springs road, *Clokey 8643;* Kyle Canyon trailer camp, *Train 1692;* below Wheeler Wells, *Clokey 7166*. Blooms in May.

11. ASTRAGALUS PRAELONGUS Sheldon, Minn. Bot. Stud. 1: 23. 1894. *A. Pattersoni* Gray var. *praelongus* Jones, Contr. W. Bot. 10: 65. 1902. *Jonesiella praelonga* Rydb. N. Am. Fl. 24: 404. 1929.

Southern Nevada and southwestern Utah; reported from the Charleston Mountains by Jones (Rev. Astrag. 156. 1923). Should be looked for on the lower foothills.

12. ASTRAGALUS MOHAVENSIS Wats. Proc. Am. Acad. 20: 361. 1885. *Brachyphragma mohavensis* Rydb. N. Am. Fl. 24: 400. 1929.

Mohave Desert, California and Nevada. Local habitat, scattered and scarce; gravelly soil in Juniper Belt at elevations from 1500 to 1800 meters: Harris Springs road, *Clokey 8687;* Kyle Canyon, *Clokey 7990, 7991*. Blooms in May.

13. ASTRAGALUS PLATYTROPIS Gray, Proc. Am. Acad. 6: 526. 1865. *Phaca platytropis* Rydb. Mem. N. Y. Bot. Gard. 1: 246. 1900. *Cystium platytrope* Rydb. Bull. Torr. Bot. Club 40: 50. 1913.

Rare on isolated peaks; Beaverhead County, Montana; Tooele County, Utah; Elko, White Pine and Clark counties, Nevada; Sonora Pass, California. Local habitat. Gravelly slopes at or above timberline on Charleston Peak at elevations of 3400 to 3500 meters; associated with *Pinus aristata:* Charleston Peak, *Clokey 5518, 7992, 8001;* southwest slope of Charleston Peak, *Train 2292*. Blooms in late July.

The Charleston Peak plants differ constantly from the typical form in the following characters: stipules 1.5–2 mm. long, leaflets 11–19, calyx teeth 1 mm. or less long. The illustration (plate 42) in "Revision of the North American Species of Astragalus" by M. E. Jones is inaccurate in showing the septum extending from the dorsal suture only. The septum is formed by protrusions from both sutures meeting in the center of the pod. The seeds are dark brown and mitten-shaped.

14. Astragalus kernensis Jepson subsp. **charlestonensis** subsp. nov. A specie differt: foliolis 15–19, leguminibus 1 cm. longis.

Caespitose, decumbent perennial; stems 1–1.5 dm. long, slender, strigose; leaves 6 cm. or less long; stipules deltoid, 2 mm. long, strigose; petioles white strigose; leaflets 15–19, well separated, elliptical to narrowly obovate, obtuse, 4–7 mm. long, strigose on the lower face, glabrous on upper; racemes axillary, shorter than the subtending leaves, 2–6 flowered; peduncles slender, 2–3 cm. long; racemes 1 cm. or less long, the inflated pods appearing capitate; flowers white except for the purple tip to the keel, 8–10 mm. long; calyx strigose with white and black hairs; the tube about 3 mm. long; teeth 0.5–1 mm. long; banner 8–10 mm. long, 4–5 mm. wide, nearly erect, entire or minutely notched at apex; wings nearly as long as the banner, blade 5–6 mm. long, 1.5 mm. wide, with reflexed, basal auricle; keel purple tipped, about 7 mm. long; blade 3.5 mm. long, with reflexed basal auricle; pods sessile, papery, strigose, mottled, 1 cm. long, septum formed by protrusions from both sutures, reaching the tip, only the ventral suture sulcate, oval to nearly globular, obtuse at both ends, with a slender beak 1–2 mm. long; seeds about 5, mitten-shaped, 2.3 mm. long, 2 mm. wide.

Known only from Charleston Peak. With *Pinus aristata,* elevation 3200 meters, July 29, 1937, *Clokey 7573* (type); west slope near Trout Creek, elevation 10,000 feet, June 26, 1926, *Jaeger* (Pomona).

The oval to spherical pods, obtuse at both ends with the partition, formed by protrusions from both sutures, reaching the tip, making the pods completely 2-celled, shows relation to *A. kernensis* Jepson not to *A. lentiginosus* Dougl. var. *sierrae* Jones or other forms near *A. lentiginosus.* These all have the partition formed by a septum, from the dorsal suture only, which does not reach the tip.

The subspecies may be separated from the species as follows:

Leaflets 11–15, pods 6–7 mm. long, 8000–8500 ft., Tulare County, California .... *A. kernensis*

Leaflets 15–19, pods 1 cm. long, 10,000–10,500 ft., Charleston Peak, Clark County, Nevada .... *A. kernensis* subsp. *charlestonensis*

15. Astragalus lentiginosus Dougl. var. Fremontii (Gray) Wats. Bot. King Expl. 66. 1871. *A. Fremontii* Gray, in Torr.

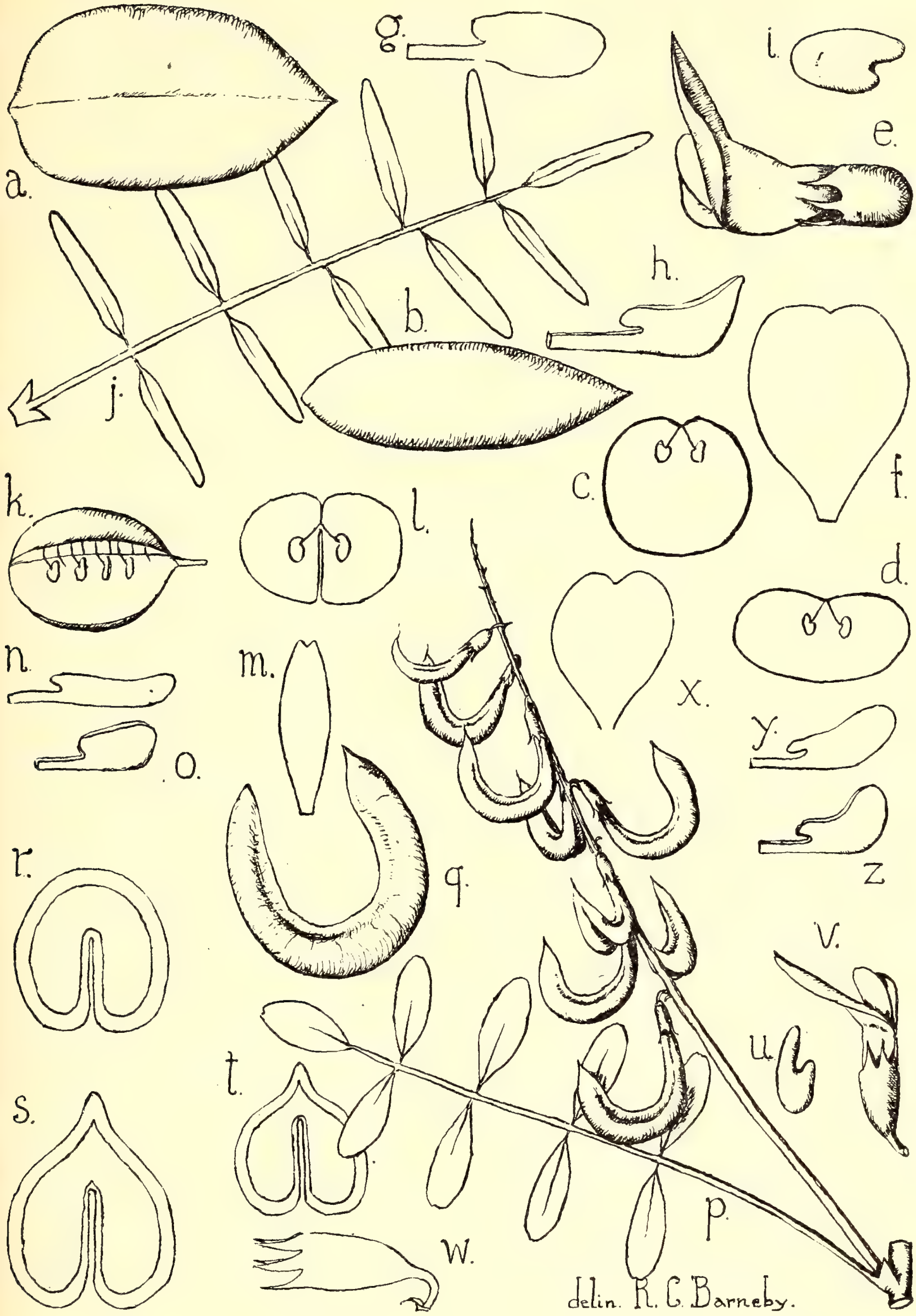

PLATE 27. ASTRAGALUS. Figs a–j, *Astragalus aequalis* Clokey: *a,* pod, dorsal view, ×1; *b,* pod, lateral view, ×1; *c, d,* cross sections of pods, ×1; *e,* flower, ×3; *f,* banner, ×2; *g,* wing-petal, ×2; *h,* keel, ×2; *i,* seed, ×4; *j,* leaf, ×1. Figs. k–o, *Astragalus kernensis* Jepson var. *charlestonensis* Clokey: *k,* longitudinal section of pod, ×2; *l,* transverse section of pod, ×2; *m,* banner, ×2; *n,* wing-petal, ×2; *o,* keel, ×2. Figs. p–z, *Astragalus hemigyrus* Clokey: *p,* raceme and leaf, ×1; *q,* pod, ×2; *r,* transverse section of fresh pod, ×5; *s, t,* cross sections of dry pods, ×5; *u,* seed, ×4; *v,* flower, ×2; *w,* calyx, ×3; *x,* banner, ×2; *y,* wing-petal, ×2; *z,* keel, ×2.

Pacif. R. R. Rep. 4: 80. 1857. *Cystium Fremontii* Rydb. N. Am. Fl. 24: 407. 1929.

Southern Utah to the Death Valley region of California, south to Mexico. Local habitat, locally abundant in rocky, brushy ground in the upper Larrea and lower Juniper belts: Kyle Canyon, *Clokey 7175, 7574, Train 1672;* mouth of Pine Canyon, *Clokey 8612;* Trout Creek fan, *Clokey & Anderson 7176;* Wilson's ranch, *Maguire 16596*. Blooms about May 1.

16. Astragalus Minthorniae (Rydb.) Jepson, Fl. Calif. 2: 374. 1936. *Hamosa Minthorniae* Rydb. Bull. Torr. Bot. Club 54: 15. 1927.

Southern Nevada to the New York Mountains, California. Local habitat, gravelly flats and slopes in the Juniper Belt at elevations from 1700 to 2200 meters: Clark Canyon, *Clokey & Anderson 7180;* Kyle Canyon, *Clokey 7177, 7575, Train 1686;* Mountains Springs, *Clokey 7997;* below Wheeler Wells, *Clokey 7179.* Blooms in May.

17. Astragalus bernardinus Jones, Proc. Calif. Acad. ser. 2, 5: 661. 1895. *Hamosa bernardina* Rydb. Bull. Torr. Bot. Club 54: 19. 1927.

Mohave Desert from the San Bernardino Mountains, California; reported from the Charleston Mountains by Jones (Rev. Astrag. 258. 1923). Should be expected on the lower foothills. Blooms in early spring.

18. **Astragalus hemigyrus** sp. nov. Herba perennis humilis frutescens argyreo-canescens; caules numerosi ramosi, 1–4 dm. alti; folia adscendentes, 5–10 cm. longa; stipulae triangulares acuminatae, 2 mm. longae; foliola 7–11, 6–15 mm. longa elliptica, apice obtuso vel retuso; pedunculi et racemi quam foliis subtendentibus paullo longiores; bracteae subulatae, 1 mm. longae; pedicelli in fructu reflexi, leguminibus horizontaliter patentibus; flores purpurei, 6–8 mm. longi; calyx strigosus, pilis albis vel nigris, tuba 3 mm. longa, dentibus subulatis, 2 mm. longis; vexillum obovatum; alae quam vexillo 1 mm. breviores, lunatae, apice rotundo, auriculo magno reflexo; carina alis aequans; legumen 2.5–3 cm. longum, 4–5 mm. latum, subsessile deciduum non inflatum valide reticulatum, uniformiter arcuatum, basi acuto, apice acuto in rostro brevi gracili attenuato, stylo curvato persistenti, biloculatum vel subbiloculatum fere ad apicem, septo crasso ex sutura dorsali extendenti, valvis immaturis crassis paullo succulentis, maturis coriaceis, sutura ventrali paullo prominenti, dorsali sulcata; semina compressa ad hilum alte emarginata, 2.5 mm. longa, 1.5 mm. lata.

Low, bushy, silvery-canescent perennial; stems numerous, branched, 1–4 dm. high; leaves ascending, 5–10 cm. long; stipules deltoid-acuminate, about 2 mm. long; leaflets 7–11, 6–15 mm. long, elliptic, obtuse or retuse; peduncles and racemes somewhat longer than the subtending leaves; bracts subulate, 1 mm. long;

flowers purple, 6–8 mm. long; calyx strigose with white and black hairs; tube 3 mm. long; teeth subulate, 2 mm. long; banner obovate; wings 1 mm. shorter than banner, lunate, rounded at tip, with a large reflexed auricle; keel the same length as the wings, rounded above to a blunt tip, with a reflexed, basal auricle; pedicels reflexed in fruit, pods horizontally spreading; pods subsessile, deciduous, not inflated, strongly reticulated, uniformly arched to a half circle, acute at both ends, tapering to a short, slender beak surmounted by the curved persistent style, when green, walls thick, somewhat fleshy, cross-section circular, dry walls leathery, cross-section cordate, ventral suture somewhat raised, dorsal suture sulcate, 2-celled or almost so nearly to the tip by a thick-walled open septum from the dorsal suture, 2.5–3 cm. long, 4–5 mm. high; seeds brown, mitten-shaped, 2.5 mm. long, 1.5 mm. wide.

Growing on rock ledges south of Indian Springs in the Larrea Belt, elevation about 1250 meters, April 18, 1939, *Clokey 8409* (type); *Clokey 7996, 8593.*

Astragalus hemigyrus is most closely related to *A. Layneae* Greene from which it may be separated as follows:

Stipules 7–10 mm. long; leaves near base of plant; leaflets 13–23, 1–1.5 cm. long; flowers white with purple tip, 15–20 mm. long; calyx 5–7 mm. long; pod 3–5 cm. long, 6–7 mm. wide, pilose-canescent with somewhat curly hairs, curvature of pod most pronounced near tip .... *A. Layneae*

Stipules 2 mm. long; leaves throughout length of stem; leaflets 7–11, 6–15 mm. long; flowers purple, 6–8 mm. long; calyx tube 3 mm. long, pods 2.5–3 cm. long, 4–5 mm. wide, strigose with short appressed hairs, curved nearly uniformly throughout .... *A. hemigyrus*

Jones (Rev. Astrag. 261. 1923) reports *A. albens* from Indian Springs, Charleston Mountains. No specimens to substantiate this record are in the Jones Herbarium at Pomona College or in the National Herbarium where many of Jones' first sets are deposited. *Astragalus albens* is a local species of the San Bernardino Mountains of California. Rydberg (Bull. Torrey Bot. Club 54: 22. 1927) calls attention to Jones' description of the pods of *A. albens* " 'arched mostly to a circle, . . . when mature coriaceous, strongly corrugated, 2–3 cm. long, 3 mm. wide and high, flat for about 1 mm. high along the ventral suture and forming a thick wing, etc.' In the type number the pod is only 1.5 cm. long, forming an arch of about one fourth of a circle, neither coriaceous nor corrugated." The type specimen and other collections from and near the type locality fit the original description. Jones' description of the pods of *A. albens* would serve for the pods of *A. hemigyrus.* It is believed that there is no justification for including *A. albens* in the flora of the Charleston Mountains.

19. Astragalus calycosus Torr. in Wats. Bot. King Expl. 66. 1871. *Hamosa calycosa* Rydb. Bull. Torr. Bot. Club 40: 50. 1913.

Western Wyoming and Idaho south to southern Nevada and eastern California. Local habitat, slopes in Juniper Belt at elevations of 2000 to 2200 meters: ridge along lower Lee Canyon, *Clokey & Bean 7589, Clokey 8002;* below Wheeler Wells, *Clokey 7163.* Blooms in June.

20. Astragalus mancus (Rydb.) Wheeler, Rhodora 40: 136. 1938. *Hamosa manca* Rydb. Bull. Torr. Bot. Club 54: 17. 1927.

Northeastern to southern Nevada. Local habitat, slopes and hilltops from timberline with *Pinus aristata* at elevations of 3300 meters to 2600 meters with *Pinus scopulorum:* Charleston Peak, *Clokey 5516;* ridge south of Deer Creek, *Clokey 8635;* between Kyle Canyon and Deer Creek, *Clokey 8000, Alexander 792b;* Lee Canyon, *LaRivers & Hancock 514, Clokey 7999, 8681, Train 2073, Alexander 792a.* Blooms in late June or July.

21. Astragalus Nuttallianus DC. var. trichocarpus Torr. & Gray, Fl. N. Am. 1: 334. 1838. *Hamosa austrina* Small, Fl. Southeast. U. S. 618, 1332. 1902.

Colorado to southern California south to Texas and Lower California. Local habitat, rocky ground in the Larrea and lower Pinyon belts at elevations below 1700 meters: Mountain Springs, *Clokey & Anderson 7985.* Blooms about May 1.

21a. Astragalus Nuttallianus DC. var. acutirostris (Wats.) Jepson, Fl. Calif. 2: 379. 1936. *Astragalus acutirostris* Wats. Proc. Am. Acad. 20: 360. 1885. *Hamosa acutirostris* Rydb. Bull. Torr. Bot. Club 54: 331. 1927.

West central Nevada to the Sierra Nevada, south to the Colorado Desert, California. Reported from the Charleston Mountains by Jones (Rev. Astrag. 271. 1923). Should be looked for on the lower foothills in the early spring.

21b. Astragalus Nuttallianus DC. var. imperfectus (Rydb.) Barneby, Leafl. West. Bot. 3: 109. 1942. *Hamosa imperfecta* Rydb. Bull. Torr. Bot. Club 54: 329. 1927.

Nevada, Arizona and Lower California. Local habitat, dry, rocky soil in the Larrea Belt: ridge east of Wilson's ranch, elevation 1320 meters, *Clokey 8712.* Blooms about May 1.

22. Astragalus dispermus Gray, Proc. Am. Acad. 13. 365. 1878. *Hesperastragalus dispermus* Heller, Muhl. 1: 137. 1906. *Astragalus didymocarpus* Hook. & Arn. var. *dispermus* Jepson, Fl. Calif. 2: 376. 1936.

Western Arizona, southern Nevada and California south to Lower California. Reported from the Charleston Mountains by Jones (Rev. Astrag. 285. 1923). Should be expected at the lower elevations. Blooms in March or April.

South Pasadena, California,
January 19, 1942.

THE TYPE LOCALITY OF POLYSTICHUM LEMMONI UNDERWOOD

Harold St. John

By detective methods it is often possible today to locate rather exactly the type locality of species described but not definitely localized by earlier botanists. These notes are written to publish more information on the type locality of *Polystichum Lemmoni* Underwood (Our Native Ferns, ed. 6: 116–117, 1900). The published type locality was "Near Mt. Shasta, California (*Lemmon*)." This appears to have been a loose usage of the geographic term, as the strikingly distinctive, but rare, fern has not been subsequently rediscovered on Mount Shasta. William B. Cooke (Am. Fern Journ. 29: 109, 1939) in his account of the ferns of Mount Shasta proper, excluded *P. Lemmoni* from the list, concluding that Lemmon's specimen, the type of the species, was probably not collected on Mount Shasta. This is in agreement with the detailed review and discussion of this type locality by Louis C. Wheeler (Am. Fern Journ. 27: 121–126, 1937). The type specimen is in the herbarium of the New York Botanical Garden. Two of the Lemmon collections there were labeled *P. Lemmoni* Underw. by Dr. L. M. Underwood, but neither definitely marked as the type. The first was collected on Mount Eddy, July 12, 1878; the second, near Shasta, California, July 1879. Dr. H. A. Gleason designated the second as the lectotype, since Shasta was the published type locality, and Dr. L. C. Wheeler at one place agreed with this choice. Wheeler discussed and cited the several Lemmon collections in different herbaria and their variously worded data and indicated that the type locality "near Shasta," did not apply to the former valley settlement called Shasta. It is apparent that duplicate collections were distributed by Lemmon with varying statements of the locality data.

The writer, while preparing a biography, has searched far and wide for botanical correspondence with Lemmon. That with C. B. Davenport does not help on this particular fern, but there is evidence in the letters from J. G. Lemmon to Professor D. C. Eaton, preserved in, and kindly made available by, the Stirling Library, Yale University.

"Sierra Valley, Cal.,
August 26, '79.

"Now for the most astonishing part of your letter—the new *Aspidium*. Is it possible that it is *distinct?* Why it is abundant in a certain valley not 30 miles west of Mt. Shasta, the old stamping ground of hosts of botanists. I will send you full specimens as I have here a fine lot, . . . I was struck by the appearance of the *Aspidium* & gathered a lot of it for it looked such a marked variety. And I fear yet it may prove a *munitum* for some of the fronds are large & approached the type—in appearance.

"Now for 'habitat, soil, moisture, exposure, abundance, scarcity?' etc. It is quite abundant on the side of the little valley at the headwaters of the South Fork of the upper Sacramento & along the south sloping side of Mt. Eddy, arising on the N. side of this valley. Protrudes from under rocks, a vast number of fronds together—more than any *munitum* I ever saw (which took my eye). The soil a dissolved granite, quite moist & loose, the inclination generally to the S. at a steep angle.

"What is very singular is that a grove of the long lost *Pinus Balfouriana* extends over the same ground, two excellent things found in one day! No objection to the name you are kind enough to propose. Nothing so fine as a fern, and such favorites with the ladies!!"

Lemmon later gave details of the occurrence of *Pinus Balfouriana* Jeffrey: "A few trees at an altitude of 7,500 feet forming a dark-green belt on the south flank of one of the eastern spurs of Scott Mt., 20 miles west of Shasta, where Jeffrey detected it in 1852 (rediscovered by the writer, in 1878; only other California localities, a few trees near the headwaters of Kings River, in the Southern Sierra." (2nd. Bienn. Rept. Calif. State Bd. Forestry 1887–88: 71, 1888). Further on (pp. 86–87) Lemmon continues, "Jeffrey noted his discovery, 'Mountains between Shasta and Scott Valley, N. Cal. Lat. 40° 30′ to 41° 51′. Elevation 5,000 to 8,000 feet.' . . . But so small are the groves, and so local their position, that they were not detected anew until August of 1878, when the writer, making his headquarters at Sisson, prosecuted a thorough search of the various intricate mountain ranges lying west of Shasta, and forming spurs of the diversified Scott Mountains. I noted the locality for publication in 'Brewer's Botany of California,' as 'on the southern flanks of the Scott range of mountains, forming a dark-green belt, from 5,000 to 8,000 feet altitude, between the light-colored *P. monticola* below and *P. albicaulis* above it.' "

It appears that at first Eaton thought the fern from "near Shasta" to be a new species and he wrote to Lemmon announcing that he would name it *Aspidium Lemmoni* in his honor. One can imagine the intense pleasure this gave to Lemmon, a fern-lover. Then, on further consideration, Eaton decided that it was not a new species but was identical with *Aspidium mohrioides* Bory of Southern Chile and Patagonia. He published this determination (Eaton, D. C., Ferns of N. Am. 2: 128, 1879; 251–254, pl. LXXX, figs. 4–9, 1880, and Torrey Bot. Club, Bull. 6: 360–361, 1879). On page 128 Eaton recounted this, "At first I believed it to be a distinct species, and proposed to name it after its discoverer, a gentleman whose own modesty has been the innocent reason why some Californian fern was not long ago named in his honor."

Wheeler (p. 122) quotes the two indefinite statements of the locality of this rare fern given by Eaton in his "Ferns of North

America," but omits the third and more detailed one (p. 252), *viz.*, "Mr. Lemmon writes that his fern grows in loose and moist granitic soil the root-stocks hidden under rocks, and a great many plants in one cluster. 'It is very abundant on the side of a little valley at the headwaters of the South Fork of the Sacramento, and along the southern sloping side of Mount Eddy, which rises on the northern side of this valley.' "

Several of the Lemmon collections seen by Wheeler were labeled Scott Valley, Siskiyou County, July 23, 1879, and Wheeler concludes (p. 123) that this is the real type locality. The Scott Mountains are a ridge connecting with Mount Eddy and running in a southwesterly direction from it. Only the northwestern slopes are in Siskiyou County. Scott Valley, drained by the Scott River into the Klamath, runs northerly from Scott Mountain and is about sixteen miles westerly of Mount Eddy. The headwaters of the Sacramento on the slopes of Mount Eddy are in Shasta County, about sixteen miles southwesterly of Mount Shasta, so the labels would indicate that Lemmon in 1879 found two localities, one on Mount Eddy collecting there on both July 12, 1878 and July 23, 1879, and one on Scott Mountain. We also have Lemmon's statement that he also found the fern in August, 1878 on the same day that he discovered a grove of *Pinus Balfouriana* on the southern side of Scott Mountain at 7,500 feet altitude. However, it is significant that in the contemporary letters and in the data on specimens furnished at the time to Gray and Eaton, that only the Mount Eddy locality is mentioned.

Wheeler (p. 123) puzzled over a printed label of one specimen indicating apparently that J. G. Lemmon and wife were collectors of a specimen dated 1879. Mr. Lemmon's name was underlined and this would seem to indicate that he alone was the collector. It can now be positively so stated, since J. G. Lemmon and Miss Sara A. Plummer were not married till late November, 1880.

Mr. Lemmon advertised for sale, specimens of "*Aspidium Mohrioides* Bory (New to North America)," on a handbill (Pacific Coast Flowers and Ferns, Distribution of 1880). He again enumerated this rare fern as *Aspidium mohrioides* Bory (Ferns of the Pacific Coast, ed. 1: 12, 1882). He named it the New Shasta Shield Fern, and located it at "Mt. Eddy, Head-waters Sacramento River; near Shasta Cal. 1879. (New Species!)." His insertion of the phrase "New Species" was quaint, to say the least, when he accepted it, upon Eaton's determination, as the old species described by Bory de St.-Vincent. Wheeler (p. 124–125) decided that this listing by Lemmon was based upon two of his own locality records, Mount Eddy, and near Mount Shasta (= Scott Valley), and this is now confirmed.

The writer has two volumes of "American Ferns," quarto sized books bound in blue cloth with the title and ornamental designs

of ferns on both cover and title page. These books have no other printed words, and no indication of author. They have on each page a pressed fern collected by Lemmon, attached by strips and with an herbarium label with data. Each contains a specimen of *Aspidium Mohrioides* Bory and a printed label form with "U. S. Pacific Slope Flora, (California). Coll. by J. G. Lemmon and wife, Oakland, California, 188–." The data is in Mr. Lemmon's handwriting. On one it is "Near Shasta, 8,600 ft. alt. Found elsewhere only in Patagonia and Falkland Is. S. Am. Jul. 1878." On the other it is, "Near Shasta. N. Cal. 'Only found elsewhere in Patagonia.' July 1883." These books were made up by Mr. and Mrs. Lemmon for sale to botanists and fern-lovers. Doubtless many of the ferns found in our public herbaria were supplied in this book form. The two books are not identical in number of species or arrangement. It is not clear just how many times Lemmon revisited his localities in the Shasta region, but he kept dried specimens of this fern in stock and it was one of his most unique and desired collections.

Dr. W. L. Jepson has informed the writer that Lemmon did not keep complete collection number books. None of any sort has survived. The sets of his plants sorted and distributed by Dr. Asa Gray were handled differently, but those isssued by Lemmon himself were selected from the duplicate stock, each set individually, when ordered. Real duplicates of a single season's collecting were thus prepared and issued over a period of decades, using whatever labels were then available, and Mr. Lemmon or Mrs. Lemmon inserting the written data (perhaps from memory) with variations in wording inevitable by this method. This doubtless explains the existence of the several apparently different habitats and localities for Lemmon's collections of this one fern in the general vicinity of Mount Shasta.

The lectotype designated by Gleason is "near Shasta, July 1879." This lectotype lacks accurate locality data, especially since it is now known that the species does not occur on Mount Shasta. Later Wheeler (p. 122) more precisely chose the type locality as Scott Valley. He was apparently influenced by the existence of a specimen from Lemmon's own herbarium, now at the University of California, labeled "Scott val. near Shasta, July 23, 1879, *J. G. Lemmon.*" This agreed with the data published by Underwood, "Vicinity of Mount Shasta, Calif." and was a specimen retained by Lemmon. Other factors, however, provide arguments against Wheeler's choice. The type specimen cannot be that in Lemmon's herbarium, but must be one of the two specimens in the New York Botanical Garden labeled as the new species by Underwood himself. The Lemmon herbarium received by the University of California was the remnant left after Mr. and Mrs. Lemmon had eked out a living by selling their specimens. The remaining collections had poor data, many of these specimens

when incorporated in the Berkeley collection could only be labeled "Lemmon Herbarium" as there was no exact statement of data found. In any case, Underwood did not study or cite these particular specimens, rather the ones in New York. It seems well demonstrated that Mount Shasta was intended as the general area and cannot have been the exact locality. Though Lemmon collected this rare fern in Scott Valley, also on the south side of Scott Mountain, and also on the south side of Mount Eddy, the latter is here proposed as the lectotype locality. It is selected because of the detailed locality data supplied contemporarily by Lemmon to D. C. Eaton, and published by Eaton [for *Aspidium mohrioides*], and of Lemmon's own listing of Mount Eddy in his Ferns of the Pacific Coast. These statements are quoted here fully on a previous page.

The exact taxonomic position of this fern continues to trouble the botanists. At first Eaton considered it a distinct species, then on reconsideration determined it as *Aspidium* [=*Polystichum*] *mohrioides* Bory, and later H. Christ agreed. Underwood separated it as a new species, *Polystichum Lemmoni* which was accepted by Piper and by Maxon. Now, Professor Fernald (Rhodora 26: 92. 1924) has made the northern plant a variety of the South American one and evaluated its characters. He classifies it as *Polystichum mohrioides* (Bory) Presl var. *Lemmoni* (Underw.) Fernald. The writer has not made a detailed revision of this group, but he recently compared the North American *P. Lemmoni* with good material of *P. mohrioides* from the far extreme of South America, and was struck by their dissimilarity. For the time being he is content to follow Underwood and Maxon, and to accept *Polystichum Lemmoni* Underwood as a species.

University of Hawaii, Honolulu,
April 14, 1942

FAR WESTERN NOVELTIES IN SALIX

Carleton R. Ball

Activities of collectors continue to bring to light hitherto unrecognized variations in willows. Continuing studies of relationships indicate a need for new combinations which better represent actual affinities. This paper contains some novelties in each category.

The abbreviations for herbaria containing specimens cited are as follows: BPI, National Arboretum Herbarium, Bureau of Plant Industry, United States Department of Agriculture; CAS, Herbarium of the California Academy of Sciences; CRB, *Salix* herbarium of Carleton R. Ball; CUA, Herbarium of the Catholic University of America; USN, United States National Herbarium; SU, Herbarium of Stanford University; UC, Herbarium of the University of California.

New Varieties of Salix pulchra Chamisso

Salix pulchra, with rather broadly elliptical leaves acute at both ends, is a species of far northwestern North America. It occurs throughout Alaska, except the southeastern portion, and in northwestern British Columbia, most of Yukon Territory, and the lower Mackenzie Valley.

Like many species of *Salix,* it exhibits both broad-leaved and narrow-leaved variations from the normal or average. The Swedish salicologist, Andersson, frequently added varieties *latifolia* and *angustifolia* when describing new species, or reviewing old ones, as in *S. Richardsonii.* The late American salicologist, Bebb, also often described one or both variations, as in *S. laevigata* and *S. glaucophylla.* More recently, Fernald has separated the Labradorean *S. cordifolia* into a series of varieties based on leaf size, shape, and pubescence. Still more recently, Schneider has erected varieties of *S. anglorum, S. ovalifolia* and others on leaf width and shape. The writer also has followed this practice in *S. lasiandra, S. lutea, S. glauca, S. reticulata* and other species. Because these variations in *S. pulchra* render difficult its complete recognition from descriptions of the more typical material, it seems desirable to describe as varieties its two chief leaf variations.

Salix pulchra Cham. var. **Looffiae** var. nov. E forma typica speciei differt foliis anguste vel late obovatis vel obovato-ovalibus, apice rotundatis vel apiculatis vel terminalibus acutis.

The variety *Looffiae* differs from the species in having its leaf-blades narrowly to broadly obovate, or obovate-oval, rounded to apiculate at apex or the distal leaves acute. Common dimensions in centimeters are: 1×2–2.5, 1.5×3–3.5, 2×3–4, 2.5×3.5–4, 3×4, 2.5–3×5 and 3–3.5×6–7.

It is a pleasure to name this willow for Ethel H. (Mrs. Henry B.) Looff of Oak Harbor, Washington, who has collected on Kodiak Island during two seasons. Her critical ecological work has done much to explain the distribution and the peculiar expression of arctic willows on that island.

Specimens referred to this variety are listed below. Most of the plants from coastal areas are recorded as of prostrate or depressed habit, but this is true also of specimens of typical *S. pulchra.* The specimen collected by Setchell appears to have been erect in habit.

Southern Alaska. Kodiak Island: Alitak, prostrate, mountain slope, eastern exposure, altitude 500 feet, May 26, 1940, *Ethel H. & Henry B. Looff 1191* (type, pistillate, CRB, 3 sheets); prostrate, southern exposure, *1198A* (CRB, pist.); decumbent, in mixed moss and grass association, altitude 75 m., *W. J. Eyerdam 2047* (CRB, pistillate); no specific locality, *Roland Snodgrass 39* (CRB); altitude 1385–2500 feet, Gulkana to Paxson, *Wm. A. &*

Clara B. Setchell 77 (CRB, UC). Western Alaska. St. Paul Island, Pribilof Islands, August 7, 1891, *C. H. Merriam* (USN); plants browsed by muskoxen, Nunivak Island, *O. J. Murie 2060* (CRB); St. Matthew Island, *Coville & Kearney 2086a* (USN); St. Lawrence Island, Northeast Cape, *Coville & Kearney 2001* (USN); King Island, Bering Sea, *J. P. Anderson 3607A* (CRB). Northern Alaska. Walker Lake, Kobuk River, August 21, 1901, *W. C. Mendenhall* (USN); Alatna River, 65 miles above mouth, July 23, 1901, *Mendenhall* (USN); Beaver, Yukon River, *W. A. & C. B. Setchell 408* (CRB, UC, USN); Circle City, Yukon River, *W. A. & C. B. Setchell 392* (CRB, UC, USN).

The more vigorous plants, like those from the Yukon River and the Alatna River (tributary of the Koyukuk), have elongated seasonal shoots with broad leaves at the outer end and relatively narrower blades below.

Salix pulchra Cham. var. **Palmeri** var. nov. E forma typica speciei differt foliis anguste oblongis vel elliptico-oblongis vel anguste elliptico-oblanceolatis, apice acutis vel acuminatis, 0.8–1.5 cm. latis, 4–6(8) cm. longis.

The variety *Palmeri* differs from the species in having narrowly oblong, elliptic-oblong, or narrowly elliptic-oblanceolate leaf blades, 0.8–1.5 centimeters wide, 4–6 or 8 centimeters long, and acute to acuminate at the apex. Common dimensions in centimeters are: 0.7 × 3.5, 0.8–1 × 4, 0.8–1.2 × 5, 1–1.3 × 6, 1.5 × 7, and 1–2 × 8.

A form described by Andersson of Sweden requires consideration. In 1858, he published a paper on American willows simultaneously in Sweden (Oefvers. Kon. Vet.-Akad. Förh. 15: 100–133) and America (Proc. Am. Acad. Arts & Sci. 4: 50–78). In the Swedish paper (p. 123), he described *S. phylicoides*, believed by Bebb to be *S. pulchra* but by Schneider to be a different Asiatic species, and added: *"-latifolia." "-angustifolia,"* without description or indication of rank. In the American paper, edited and annotated by Asa Gray, these entities are called forms and described (p. 64). The second reads: "Forma *angustifolia:* foliis 1–2 pollicaribus ½ poll. latis lanceolatis integerrimis." Gray doubtless got this information from Andersson. In his Monographia Salicum, 1867, Andersson described this form as "*angustifolia:* foliis lanceolato-linearibus, 4–5 pollices longis medio ½–¾ poll. latis. . . ." In his treatment of world Salices (DC. Prodromus 16 fasc. 2: 190–323. 1868), he writes "2, *argentifolia:* foliis lanceolato-linearibus 2–3 poll. longis. . . ." (p. 245).

The name *argentifolia* doubtless was a typographical error but the striking discrepancies in leaf length remain unexplained. No localities or collectors are cited in any paper. Because of this omission, the discrepancies noted, and the uncertain identity of *S. phylicoides,* Andersson's form must be disregarded.

The specimens referred to var. *Palmeri* are listed below. The

variety apparently is most common in a belt extending south to north through central Alaska, with an outlier to the west on Norton Sound and to the east on the Arctic Coast of northeastern Yukon Territory. The type (*Palmer 121*) was collected in the Matanuska Valley of south-central Alaska. Another specimen of the type collection is in the herbarium of the Fish and Wildlife Service at the Research Laboratory of the Patuxent Wildlife Refuge near Beltsville, Maryland. It is a pleasure to name this variety for L. J. Palmer of the United States Fish and Wildlife Service at Fairbanks, whose collections of plants browsed by moose and reindeer have done much to increase our knowledge of their distribution, ecology, and taxonomy.

South-central Alaska. Alaska Peninsula, Kukak Bay, *Coville & Kearney 1633* (CRB, USN); Kenai Peninsula, between Skilak and Tustumena lakes (moose-browse reconnaisance), *L. J. Palmer, 1, 6, 22, 32, 36, 56, 66* (CRB); Olga Bay, Kodiak Island, altitude above 1600 feet, *E. H. & H. B. Looff 356* (CRB); mountain shrub type, Matanuska Valley, *Palmer 121* (CRB, type); Richardson Highway, Gulkana to Paxson, *W. A. & C. B. Setchell 81* (CRB, UC); Summit Lake, *W. A. & C. B. Setchell 105* (CRB, UC); Mount McKinley National Park, Savage River Headquarters, altitude 3800–4200 feet, *W. A. & C. B. Setchell 185, 186, 189, 193* (CRB, UC). West-central Alaska. Norton Sound: Egavik, August 11, 1931, *C. H. Rouse 13, 14* (CRB); Pastolik Reindeer Camp, *Rouse 26* (CRB). Central Alaska. Vicinity of Fairbanks: Pedro Dome, altitude 2800 feet, August 11, 1909, *R. S. Kellogg* (USN); McKinley Creek, tributary of Forty-mile River, *Murie 141* (USN). Steece Highway, Fairbanks to Circle City, Twelve-mile Summit, altitude 3225 feet, *W. A. & C. B. Setchell 551* (CRB, UC). Yukon Territory. Near delta of Mackenzie River, Mackenzie Bay, Shingle Point, 69 north lat., 137 west long., *A. Dutilly 18141* (CUA), *18143, 18144* (CRB, CUA).

New Specific and Varietal Combinations

Following study of more adequate material, it often becomes necessary to elevate varieties to specific rank, to degrade specific entities to varietal rank, or to transfer varieties from one species to another. Changes of all three kinds are made herein.

Salix Walpoleii (Coville & Ball) comb. nov. *Salix Farrae Walpoleii* Coville and Ball, Bot. Gaz. 71: 435–436. 1921.

It was a mistake to arrange this northern willow as a variety of the more southern species belonging to Section Cordatae. Further study and more abundant material show that it is most closely related to *S. pyrifolia* Andersson (*S. balsamifera* Barratt), which Schneider separated from the Cordatae and made the basis of a new section, Balsamiferae. Our plant, however, appears to be more properly regarded as a second species in that section than as a variety of *S. pyrifolia*.

The description given at the time of varietal publication still is reasonably adequate. The branchlets are somewhat more pubescent than was then indicated, the distal leaves on vigorous shoots may be subovate and rounded at base, the stipules reach 8 millimeters, and the styles sometimes are 0.4 millimeters long. A comparison of some contrasting characters of *S. pyrifolia* and *S. Walpoleii* is given below.

Organ	*S. pyrifolia*	*S. Walpoleii*
Young branchlets	glabrous	more or less pubescent
Blades		
shape	ovate or ovate-lanceolate	elliptical-lanceolate to obovate
base	cordate or rounded	acute or distal roundish
margin	serrulate or crenate-serrulate	entire or remotely crenulate
venation	shallowly rugose	reticulate
Stipules	wanting or minute	2–6 or 8 mm. long
Pistillate aments	3–8 cm. long	2–5 or 6 cm. long
Capsules	7–9 mm. long	5–7 mm. long
Pedicels	2.5–3.5 mm. long	1.0–1.5 mm. long

The known range of this plant has been greatly extended since 1921. The nine specimens then listed were all from northwest Alaska and ranged in location from Seward Peninsula at Bering Strait to the Dall River north of the Yukon River, at about 150 west longitude. More recent collections have extended its recorded range far to the south and east, as shown below.

West-central Alaska. Seward Peninsula and adjacent Yukon Valley: Seward Peninsula, 1900, *A. J. Collier* (USN); vicinity of Port Clarence: north side and east end of Grantley Harbor, *F. A. Walpole 1594* (USN); rocky banks, northwest shore of Imunik Basin, July 30, 1901, *Walpole 1624* (CRB, photo; USN, pistillate type); banks of Tuksuk Channel, August 5, 1901, *Walpole 1742* (CRB, USN staminate type); Cape Nome, summer 1900, *F. E. Blaisdell* (USN); gravelly bluff near road, Hastings Creek, *C. W. Thornton 614* (USN); near Nome, *Thornton 630* (CRB, USN); tundra, Nome, *George N. Jones 9043B* (CRB). Kaltag, Yukon River east of Norton Sound: bank of Yukon River, *Rouse 45* (CRB); water's edge, *W. A. & C. B. Setchell 457–459* (CRB, UC). North-central Alaska. Valley of Kobuk River, near camp, August 20, 1901, *W. C. Mendenhall* (USN); Valley of Alaskuk River, 30 miles above mouth, July 21, 1901, *Mendenhall* (USN); Valley of Alaskuk (Alatna?) River, along Help-me-Jack Creek, near camp, July 26, 1901, *Mendenhall* (USN); Dall River, 75 miles above mouth, June 25, 1901, *Mendenhall* (USN, 2 sheets); Wiseman, middle fork of Koyukuk River, *J. P. Anderson & G. W. Gasser 5815* (CRB). East-central Alaska. Steece Highway, Fairbanks to Circle City: creek near Twelve-Mile Roadhouse, altitude 2450 feet, *W. A. & C. B. Setchell 530, 534b* (CRB, UC); Faith Creek, some distance below Twelve-Mile Summit, to Cleary Summit, altitude 2600–2700 feet, *W. A. & C. B.*

Setchell 555, 561 (CRB, UC); Twelve-Mile Roadhouse, *Anderson 2433* (CRB). Mt. McKinley National Park: Igloo Camp, altitude 2600 feet, *W. A. & C. B. Setchell 173* (CRB, UC); stream banks near Park Headquarters, *Aven Nelson 3595, 3604* (CRB); Cantwell, southeast corner of Park, *Nelson 4215* (CRB). Richardson Highway: Rapids Roadhouse, altitude 2130 feet, *W. A. & C. B. Setchell 110, 120* (CRB, UC); altitude 2700–3000 feet, Paxson, *W. A. & C. B. Setchell 87, 90, 95* (CRB, UC). MACKENZIE, NORTHWEST TERRITORY. Alkavik, 68 deg., 13 min. north lat., 135 deg. west long. *A. Dutilly 18054* (CRB, CUA), *18055* (CUA); the common willow of alluvial ridges, Mackenzie Delta, Pete's Creek, east side of Richards Island, between 69 and 70 deg. north lat., *J. J. Lynch & C. E. Gilliam 1605* (Herbarium of United States Fish and Wildlife Service).

SALIX HINDSIANA Benth. var. **leucodendroides** (Rowlee) comb. nov. *Salix macrostachya leucodendroides* Rowlee, Bull. Torr. Bot. Club 27: 250, pl. 9, fig. 6 (doubtfully representing this variety). 1900; Abrams, Fl. Los Angeles 102, 1904 (at least in part); *ibid.*, Suppl. ed. 102. 1911. *S. argophylla* Nutt. *sensu* Rowlee, Bull. Torr. Bot. Club 27: 251, pl. 9, fig. 7. 1900 (in part); Abrams, *ibid.* 102. 1904 (probably in part); Jepson, Man. Fl. Pl. Calif. 264. 1923 (in part), not of Nuttall. *S. exigua virens* Rowlee, Bull. Torr. Bot. Club 27: 255. 1900 (in part). *S. integrifolia leucodendroides* Rowlee, Bull. Torr. Bot. Club 27: 250. 1900 (*nomen nudum*). *S. longifolia* Muhl. *sensu* Parish, Zoe 4: 347. 1894 (in part, as indicated by localities), not of Muhlenberg. *S. longifolia argyrophylla* Anders. *sensu* Jepson, Mem. Univ. Calif. 2: 178. 1910 (in part), not of Andersson. *S. sessilifolia* Nutt. *sensu* Britton and Shafer, No. Amer. Trees, 156. 1908 (in part); Jepson, Mem. Univ. Calif. 2: 178. 1910 (in part), not of Nuttall. *S. sessilifolia leucodendroides* (Rowlee) Schneider, Bot. Gaz. 65: 26. 1918, *ibid.* 67: 319–322. 1919 (synonymy, discussion and citation of specimens), Jour. Arn. Arb. 3: 64, 86 (and pages cited for *S. sessilifolia*). 1922; Ball in Abrams, Illus. Fl. Pac. States 1: 491 (discussed under *S. Hindsiana* Bentham). 1923; Jepson, Man. Fl. Pl. Calif. 264. 1923.

The variety *leucodendroides* differs from the species in having longer, relatively narrower, more pointed, and always remotely denticulate leaves, usually less densely pilose capsules and flower scales, and less evident styles.

Seasonal shoots usually densely white-pubescent, older branchlets less so; blades linear to linear-elliptical, 5–8 cm. long and 4–7 mm. wide or, on vigorous shoots, 9–10.5 cm. long and 6–8 or 9 mm. wide, common sizes, 4×0.5, 5×0.4–0.5, 6×0.4–0.6, 7×0.5–0.7, 8×0.5–0.7, 9–10×0.6–0.8 cm., short-acuminate at apex, tapering at base into a short petiole, always remotely denticulate, especially on the outer half, the teeth sometimes subspinulose, densely pilose-pubescent and usually silvery when

young, becoming more thinly clad by expansion, and frequently becoming more or less glabrate and greenish with age (and then often referred to *S. exigua virens* Rowlee); aments coetaneous, leafy-peduncled, solitary or 2–4 together; peduncles 1–5 cm. long in flower, the pistillate up to 8 cm. long in fruit; staminate aments 1 or usually 2–3, or occasionally 4, on one peduncle; pistillate aments 1 or 2 together, 2.5–4 or sometimes 5–6 cm. long; capsules lanceolate, 5–5.5 or 6 mm. long, closely sessile or occasionally very short-pedicelled, densely to thinly pilose, often becoming glabrate and brownish in age; styles scarcely evident or 0.1–0.3 cm. long; stigmas 0.5–0.7 mm. long, divided and reflexed.

For convenience, the brief description and discussion given by Rowlee for his new variety are quoted here.

"One to three meters high, wood soft: leaves much larger, 10–12 cm. long, 1 cm. wide, densely white tomentose on both sides, largest remotely denticulate: aments larger, cylindrical, 4–5 cm. long, otherwise as in the type."

"*S. integrifolia* var. *leucodendroides* is a very striking form from southern California collected by Mr. S. B. Parish, nos. 2134, 2040, and 640. There does not seem to be enough difference to warrant its separation as a species although intergrading forms are wanting."

The above description and discussion of variety *leucodendroides* leave much to be desired. First, Rowlee redescribed the common California long-leaf willow, *Salix Hindsiana* Bentham, under the name *S. macrostachya* Nuttall, a plant of the Columbia River Valley, and cited several California specimens. Then he asserted that, from the description, Bentham's California plant is the same as *S. argophylla* Nuttall, another plant from the Columbia Valley. The facts are that *S. macrostachya* is a synonym of *S. argophylla* and that *S. Hindsiana* Bentham is a good species, confined to California and adjacent Oregon and much more closely related to *S. sessillifolia* Nuttall, of Oregon and Washington, than to *S. argophylla.* Finally, the leaf size given by Rowlee is much larger than the average and denticulation is not confined to the larger leaves but is universal. The result was to confuse readers as to the characters and relationships of his variety. As the plant Rowlee held to be *S. macrostachya* really is *S. Hindsiana* Bentham, the present combination merely accomplishes what Rowlee thought he was doing.

His reference to a species, *S. integrifolia,* in the discussion above, is wholly without meaning. It seems probable that Rowlee contemplated renaming Bentham's plant, which has entire leaves, but later decided it was Nuttall's *S. macrostachya.*

Rowlee obviously did not designate a type, although he cited three collections by Parish (see above). The writer has seen a specimen of number 2040 in the herbarium of the University of California (sheet 55027). On the label, the word "Type" has

been written in Rowlee's own hand. There are two specimens of number 640 in the United States National Herbarium (sheets 780021, 940755). They are var. *leucodendroides* but there is no evidence that Rowlee ever saw them.

Variety *leucodendroides* occurs sparingly in at least five counties in the Coast Range and central basin of California north of the Tehachapi, where the species is common. It occurs more abundantly in all of the counties south of this divide, where the species is much less common. Several specimens from Humboldt County, in the northwestern part of the state, have been referred to this variety but they need further study and are not cited here.

In the western part of southern California this variety is the dominant representative of section Longifoliae, the long-leaf or sandbar willows. To the eastward it gradually is replaced by varieties of *Salix exigua* Nuttall. In the northern edge of its southern range it overlaps the range of the species. On the south it extends into Lower California and on the east into the edge of Arizona. Its altitudinal range is from approximately sea level along the Colorado River and the southern coast to elevations of approximately five thousand feet in the southern mountains.

Because specimens of variety *leucodendroides* are seldom correctly identified, but usually are found under such names as *argophylla, argyrophylla, exigua, Hindsiana, longifolia, macrostachya,* and *sessilifolia,* it is desirable to cite the numerous specimens which have been referred to it by the writer:

California (counties from north to south). Santa Clara County. Upper east fork, Coyote Creek, *W. R. Dudley 4207* (CAS). San Benito County. Creek east of Lookout Mountain, altitude 3300 feet, *Hall 9926* (USN); The Pinnacles, *Eastwood 6750* (CAS); San Juan, *Elmer 4908* (CAS, USN). Monterey County. Nacimiento River, *Brewer 544* (USN). Tulare County. Kern River, Peppermint Valley, altitude 4800 feet, *Dudley 779* (SU); Three Rivers, near Britton's, June 15, 1902, *Dudley* (SU). Kern County. Bakersfield, *Piper 6406* (USN), *E. A. McGregor 13* (SU); Santa Fe Railroad, west of Bakersfield, *Heller 7591* (SU, 2 sheets; UC). Ventura County. Santa Ynez Mountains: Matilija Canyon, 6.5 km. below Matilija Hot Springs, altitude 270–300 meters, *Fosberg 7423, 7425* (CRB, 2 sheets each; USN, UC); Matilija Canyon, Ojai Valley, altitude 270 meters, *Mrs. H. P. Bracelin 633–636* (CRB, 3 sheets of each; USN, UC); Shady (?) Canyon near Ojai, altitude 600 feet, May 22, 1866, *S. F. Peckham;* Sespe, *F. W. Hubby 134, 135* (label reads "Santa Barbara Co.") (SU); Sespe Canyon, September, 1914, *B. W. Everman* (CAS); Piru Creek, 10 miles above Piru, *Ralph Hoffman 354* (CRB); Piru Creek, 5 km. above Piru, altitude 270 meters, Santa Barbara National Forest, *Fosberg 7426* (CRB, 4 sheets; USN, 3 sheets); east of Piru, altitude 180 meters, *Bracelin 629* (CRB, 2 sheets), *630, 631* (CRB, 2 and 3 sheets; USN, UC); Hueneme, April 7, 1902,

Burtt-Davy (UC); Oxnard, Patterson Ranch, *Burtt-Davy 7630* (UC); delta plain, Santa Clara River, *Hoffman 181* (CRB); Ventura, along beach, *Eastwood 5034, 5035* (CAS). LOS ANGELES COUNTY. San Gabriel or Sierra Madre Mountains and their southern foothills: Arraster, altitude 2750 feet, May 10, 1919, *F. W. Peirson* (CRB); Castaic Creek, below Castaic, *Fosberg 7411, 7413* (CRB, USN, UC); Gorman, *C. R. & B. S. Ball 2526* (CRB, 3 sheets; USN, UC); Saugus, *Elmer 3650* (USN); Burbank, 1904, *J. C. Nevin* (SU). San Gabriel Mountains: canyons of Sierra Madre Mountains, May, 1888, *Hasse* (USN); Little Tujunga Canyon (near Burbank), *P. Parney 233* (CAS); San Gabriel Wash, altitude 700 feet, March 6, 1921, *Peirson* (CRB); Tujunga Canyon, altitude 1300 feet, March 30, 1919, *Peirson* (CRB); Tujunga Wash, Stonehurst, San Fernando Valley, *Fay A. MacFadden 11047* (CRB); Verdugo Hills, La Tuna Canyon, *MacFadden 3069* (SU, UC), *11044* (CRB); west fork of Garapito Creek, altitude 1150 feet, *Ewan 4219* (CRB); Puddingstone Canyon, San Jose Hills, *Wheeler 1723A, 1723B* (CRB). Santa Monica Mountains: between Calabasas and Agoura, *Fosberg 5850* (CAS, CRB, 3 sheets; USN, SU, UC, 3 sheets). Los Angeles and vicinity: Elysian Park, *George B. Grant 2294* (SU), *1156* (UC); Los Angeles River bottom, June, 1888, *Hasse* (USN), September 9, 1917, *F. Grinnell, Jr.* (SU); El Monte, altitude 300 feet, *Johnston 1242* (SU); Englewood, *Abrams 1493* (SU, 2 sheets). Mohave Desert: Lovejoy Dam, Lovejoy Buttes, *Peirson 9859* (CRB). SAN BERNARDINO COUNTY. Mojave Desert: Cushenberry Canyon, *Parish 4931* (SU, on sheet 51351 with *S. exigua*); 1.5 miles north of Victorville, altitude 815 meters, *Bracelin 597, 598* (CRB, 2 sheets, USN, UC); Helendale (Judson), Mojave River, *Bracelin 591* (CRB), *592* (CRB, USN); Hesperia, Mojave River bed, *G. I. Moxley 950* (USN). San Bernardino Mountains and foothills: Waterman Canyon, *Shaw & Illingsworth 4* (SU); mouth of Waterman Canyon, altitude 1500 feet, *Parish 11401* (UC); borders of streams, altitude 1200 feet, *Parish 11763* (UC); Keenbrook, Cajon Pass, *Parish 4930* (SU); Cajon Pass, *Abrams & McGregor 694* (SU). San Gabriel Mountains: Cucamonga Canyon, altitude 3000 feet, *Johnston 1241* (SU); Red Hill near Upland, *Johnston 1243* (SU). San Antonio Mountains: Prairie Fork of San Gabriel River, altitude 5000 feet, *Johnston 1685* (SU). San Bernardino and vicinity: San Bernardino, *P. B. Kennedy 1673* (CAS), *Marian L. Campbell 45, 46* (CAS); altitude 1000–2500 feet, *Parish 4591, 4592* (SU); Santa Ana River, altitude 1000 feet, *Parish 4786, 4787* (USN, SU), *5197* (SU), *Alfred Rehder 158* (CAS); San Bernardino Valley, *S. B. & W. F. Parish 640* (USN, 2 sheets; this number cited by Rowlee), altitude 300 meters, *Parish 11134* (UC); Colton, May 20, 1882, *M. E. Jones* (CAS, CRB, UC); Chemehuevis Valley, *Jepson 5208* (SU). ORANGE COUNTY. Los Alamitos: July 20, 1908, *I. J. Condit* (UC, 2 sheets); Bixby Avenue, west of Hansen

Road, *C. R. Wolf 3843, 3845* (CRB, USN, UC). Santa Ana River: Santa Ana, *Helen D. Geis 553, 554* (SU); Santa Ana Canyon, altitude 500 feet, *J. T. Howell 2440* (CAS, 2 sheets), altitude 120 meters, *Wolf 2953, 2954* (CRB, USN, UC). Riverside County. Riverside and vicinity: Santa Ana River near Riverside, May 20, 1888, *Parish 2040* (type?) (UC), *H. DeForest 3* (CRB); Santa Ana River near Corona, *Crawford and Johnston 1244* (SU); Santa Ana River, altitude 500 feet, *Peirson 4282* (CRB); Santa Ana River, 4.8 km. north of Arlington, altitude 240 meters, *Bracelin 599, 602, 604* (CRB, USN, UC), *605, 606* (CRB, 2 sheets each). San Jacinto, June, 1921, *Ethel H. Campbell* (CAS); San Jacinto Mountains, east base, along borders of Colorado Desert, *Hall 2105* (SU, UC); San Jacinto Valley, June, 1897, *George F. Reinhardt* (UC); San Jacinto River Canyon, Oak Lodge, altitude 3000 feet, *Parish 11702* (UC). Colorado Desert, Thousand-Palm Canyon, *DeForest 2* (CRB). San Diego County. Mountain Spring (International Boundary Commission, United States and Mexico), *Edgar A. Mearns 3040* (USN, SU); near Tia Juana River, Tia Juana, August, 1902, *A. C. Herre* (SU), *Abrams 3485* (SU); near Tia Juana, June, 1895, *S. G. Stokes* (SU); San Diego River, San Diego, *Abrams 3419* (SU); Old Town, *Bracelin 620–623, 625–628* (CRB, 1 to 3 sheets each; USN, except last 3; UC); flats of San Luis Rey River, west of the Mission, *Wiggins 3034* (SU; UC, 2 sheets); Jacumba Valley, *Abrams 3679* (SU); Laguna Mountains, *Eastwood 9253* (CAS); Lakeside, *Grant 6860* (SU); Oneonta, altitude 25 (?) feet, *H. P. Chandler 5116* (SU); Warner's Hot Springs, *Eastwood 2822* (CAS). Imperial County. Colorado River bottoms, 10 miles from Yuma, Arizona, *Roxana S. Ferris 1030* (SU, 2 sheets).

Mexico. Baja California, near Tia Juana, *M. E. Jones 3730* (CAS).

Salix Hindsiana var. **Parishiana** (Rowlee) comb. nov. *Salix Parishiana* Rowlee, Bull. Torr. Bot. Club 27: 249, pl. 9, fig. 3. 1900; Abrams, Fl. Los Angeles, suppl. ed., 101. 1911; Schneider, Bot. Gaz. 67: 323–325. 1919, Jour. Arnold Arb. 3: 65, 92, 98. 1921; Ball in Abrams, Illus. Fl. Pac. States 1: 492, fig. 1198. 1923. *S. exigua* var. *Parishiana* (Rowlee) Jepson, Man. Fl. Pl. Calif., 264. 1923.

Rowlee drew a fairly adequate description of his new species, *Salix Parishiana,* when it is considered that the foliage and aments of the type were not yet fully developed. For convenience of discussion and comparison it is reproduced here:

"A slender shrub, one to three meters high, bark grayish or brown, young twigs cinereous strigose: leaves linear-lanceolate, minutely and remotely denticulate, 5–7 cm. long by 3 mm. wide, silky canescent when young, glabrous and somewhat coriaceous when mature, veins few but very prominent: stipules none: aments on long leafy peduncles, appearing about April 1, 2–3 cm.

long by 1–2 (*sic*) cm. peduncles often 10 cm. long, the upper leaves of the branch much surpassing the ament: ament densely flowered, scales white densely villous all over, oblong, acute: filaments scantly (*sic*) hairy at the base: capsules densely villous, oblong, closely sessile: style distinct: stigmas linear, three times as long as thick.

"A very peculiar form, differing from *S. taxifolia* by its larger leaves and cylindrical aments and quite distinct from other species with linear stigmas.

"California: Matilija Cañon, San Bernardino Co. (F. W. Hobby (*sic*), nos. 54, 55), Springs Valley, Inyo Co. (F. V. Coville and F. Funston, no. 263)."

Had Rowlee studied the more mature material, with the consequent larger and more evidently denticulate leaves and larger aments, he scarcely would have compared his species with *S. taxifolia* alone. Nor would he have stated so positively that it was "quite distinct from other species with linear stigmas." The type, as so frequently is the case, represents an extreme form of the entity.

Certain characters assigned by Rowlee, such as the glabrousness, linear-lanceolate shape, and veininess of the mature leaves, must have been observed in the collection by Coville and Funston from Inyo County (no. *263*), as they are not exhibited by the type specimens. Number *263* probably is a desert form of *S. exigua,* as suggested by Schneider, who in turn considered *S. Parishiana* probably to be intermediate between *S. exigua* as it occurs in southern California and *S. sessilifolia* var. *leucodendroides.*

Through the courtesy of Dr. A. J. Eames and the late Dr. K. M. Wiegand, the types of *Salix Parishiana* Rowlee were made available to the writer from the herbarium of Cornell University. Both types, male and female, are mounted on one sheet. The label reads as follows: "S. longifolia, var. argyrophylla And., Pistillate fl., Cliff Glen; staminate fl., Ojai Hot Spgs., Matilija Cañon, Sta. Barbara Co., F. W. Hubby, No. 54, April 3, 1896." In the upper right corner are pencilled the words: "S. parishiana n. sp. W. W. R.". A second sheet bears a single more nearly mature pistillate specimen and a label reading: "Salix longifolia var. argyrophylla as to leaf characters; S. sessilifolia var. hindsiana as to style and stigma. Matilija Cañon, Kennedy's, Sta. Barbara Co., F. W. Hubby, No. 55, April 19, 1896." It has the same pencilled annotation as the first label, and both annotations are in Rowlee's handwriting. The first cited collection by Hubby (no. *54*) consists of a male (type) shoot 38 centimeters long with a half dozen aments, and a female (type) shoot 30 centimeters long with some five aments. The second cited collection by Hubby (no. *55*) is a single pistillate shoot about 24 centimeters long, with two aments. On each of the herbarium sheets is the inked annotation "S. parishiana n. sp., WWR." in Rowlee's hand.

From these three specimens, all from Matilija Cañon, and all annotated by Rowlee and cited with his original description, it is possible to give the following emended description.

Aspect gray or silvery-gray; seasonal branchlets puberulent to pubescent, those of the first year glabrate to puberulent; leaves subpetiolate, exstipulate, blades linear (not linear-lanceolate), 4–7 or 8 cm. long, 2–3.5 mm. wide, common sizes 5×2.5, 6×2.5–3.5, 7×2–3, 8×3.5, acute at base and apex, margins somewhat revolute, remotely and minutely denticulate, the midrib and primary veins slightly raised (not 'very prominent') on the gray to silvery puberulent upper surface, the lower surface silvery pubescent (leaves immature and therefore not 'glabrous and coriaceous when mature'); pistillate peduncle 2–3 cm. long in flower to 4 cm. long in fruit, the staminate 7–10 cm. long in flower, each bearing 8–10 foliage leaves; pistillate aments 2 cm. long in flower, 3 cm. long, 1 cm. wide in fruit (not '1–2 cm.'); capsule (no. *55,* nearly mature) narrowly lanceolate (not 'oblong'), 4.5–5 mm. long, sessile, pilose, style evident but very short, 0.1–0.2 mm. long, stigmas linear-oblong, 0.5–0.6 mm. long, divided, spreading; flower scales broadly elliptical or elliptical-oblanceolate, 2–2.5 mm. long, thinly pilose-pubescent or subglabrate on the outside, more pilose-pubescent within (not 'densely villous all over'); staminate aments about 2 cm. long and 0.5 cm. wide; stamens two, filaments free or united only at the extreme base, pilose with crinkly hairs on the lower half or two-thirds; ament scales as in the pistillate ament.

Variety *Parishiana* apparently is confined to the southern coastal district of California and occurs chiefly in the mountains from relatively low elevations to five thousand feet above sea level. Present material indicates a range from the Pinnacles in San Benito County to San Diego County at the international boundary. Specimens of the variety are found in herbaria under the names of various species of section Longifoliae, as *argophylla, exigua, Hindsiana, longifolia, macrostachya, sessilifolia* and their varieties.

California. San Benito County. Stream bank, Pinnacles, *J. T. Howell 4620* (CAS); Bear Valley, Pinnacles, *Chester Dudley 6* (CAS). Ventura County. (Matilija Canyon is a tributary of the Ventura River, whereas all other streams mentioned are part of the Santa Clara River system.) Matilija Canyon, Cliff Glen (male type), Ojai Hot Springs (female type), April 3, 1896, *F. W. Hubby 54;* Kennedy's, April 19, 1896, *Hubby 55* (types, Cornell University; photographs, CRB, UC); Matilija Canyon, 6.5 km. below Matilija Hot Springs, Santa Ynez Mountains, altitude 270–300 meters, *Fosberg 7424* (CRB, 2 sheets; USN, UC); Sespe Creek (between Sulphur and Pine mountains), near Ten-Sycamore Flat, altitude 2300–2500 feet, *Abrams & McGregor 169* (SU, male and female; leaves 5–7 cm. $\times$ 3–4 mm., style 0.2–0.4 mm. long, stigmas

1 mm. long); Mount Pinos (near center of northern boundary of Ventura County, its eastern flank drained by Lockwood Creek, a tributary of Piru Creek): Lockwood Creek, below Snedden's, *Dudley & Lamb 4632* (SU, bearing cone galls); Goodenough Meadow, *Dudley & Lamb 4717* (SU, leaves on fruiting branchlet 4–7.5 cm. × 2–3.5 mm., style 0.1–0.2 mm. long; UC, "near Lockwood Valley Schoolhouse, June 26"); Lockwood Creek, June 5, 1930, *Hoffman* (CAS); Seymour Creek, altitude 5300 feet, *Hall 6343* (UC); 3.2 km. east of Piru, altitude 180 m., *Bracelin 632* (CRB, 2 sheets; USN, UC). Los Angeles County. San Francisquito Canyon, *Parish 1984* (UC); San Antonio Mountains, Prairie Fork of San Gabriel River, altitude 5000 feet, *Johnston 1685* (UC, sterile, leaves shorter and broader than normal); near Camp Rock Creek, Pinyon Ridge, San Gabriel Mountains, altitude 4500 feet, *Peirson 716* (CRB). Orange County. Los Alamitos, July 20, 1908, *Condit* (UC). San Diego County. Tia Juana, *Eastwood 2926* (CAS).

United States Department of Agriculture,
Washington, D. C., October, 1941.

NOTES AND NEWS

The members of the University of California Expedition to El Salvador, under the capable and energetic leadership of Dr. R. A. Stirton of the Department of Paleontology, returned to the United States on May 25, 1942 after nearly six months of successful work in El Salvador. The party was hospitably and graciously received wherever it went. Two men, in particular, were of constant and invaluable assistance,—Dr. Mario Lewy of the Department of Agriculture of El Salvador and Mr. G. A. Swanquist of San Miguel.

The personnel was as follows: Mr. John Davis, herpetologist; Mr. William K. Gealey, geologist; Mr. Nathan Geer, cook and assistant paleontologist; Mr. Milton Hildebrand, mammalogist; Mr. Joe T. Marshall, ornithologist; Dr. R. A. Stirton, paleontologist; and Mr. John M. Tucker, botanist, representing the Herbarium of the University of California.

PROCEEDINGS OF THE CALIFORNIA BOTANICAL SOCIETY

February 21, 1942. The annual dinner meeting of the Society was held at the Berkeley Women's City Club on Saturday evening. About fifty members and guests were present. Dr. Alva R. Davis, President, acted as toastmaster and introduced with felicity the speaker of the evening, the distinguished mycologist, Dr. A. H. Reginald Buller, Professor Emeritus of Botany, University of Manitoba, and Hitchcock Professor, University of California, 1942. Dr. Buller discussed the ink fungi—species of the distinc-

tive genus *Coprinus* (Pers.) Fr.—and their organization, in a lucid and thoroughly interesting manner. The lecture was abundantly illustrated by slides from excellent field photographs and from Dr. Buller's drawings. The arrangements for the dinner were made by Dr. G. Ledyard Stebbins, Jr., Chairman of the Program Committee. The unique mycological table decorations were collected and arranged by Miss Beryl Schreiber, Mrs. Vera Miller, and Mrs. Lincoln Constance. Relatively few members living at a distance from Berkeley attended the banquet. The existing state of war and the consequent danger and inconvenience of possible "blackouts" are known to have lowered attendance.

March 19, 1942. Speaker: Mr. M. W. Talbot, California Forest and Range Experiment Station. Subject: Guayule and other western American rubber plants. The speaker lucidly described the Government's guayule (*Parthenium argentatum*) plantation project now being developed in the Salinas Valley. The first objective of the project is to prepare a 700-acre nursery, and to plant all available seed of selected high-yielding guayule strains. When cut at a normally economic age the best strains of guayule yield from 1200 to 2000 pounds of rubber per acre. It is expected that in two years the present program will lead to production of some 56,000 tons of rubber, and a great amount of seed of selected strains. Even before the supply of *Hevea* plantation rubber was largely cut off, guayule rubber was approaching normal economy. Following the talk a lively discussion developed with Mr. Talbot, Dr. Fred E. Foxworthy, retired Malayan forester; Dr. Trumbull of the Goodrich Rubber Company; Dr. D. T. MacDougall of Carnegie Institution of Washington, Dr. A. R. Davis, and others participating. The meeting was attended by about ninety members and guests.

April 16, 1942. The "Annual Living Plant and Specimens Meeting" was held under the direction of Dr. G. Ledyard Stebbins, Jr. Prior to the presentation and inspection of specimens, Dr. A. R. Davis presided over a short business meeting. Many interesting native and exotic plants and plant specimens were exhibited and described by a score or so of the Society's members, including Dr. G. L. Stebbins, Jr., Miss E. E. Morse, Prof. W. W. Mackie, Prof. H. W. Shepherd, Prof. H. E. McMinn, Dr. H. L. Mason, Mr. L. L. Edmunds, Dr. L. Constance, and others.

May 21, 1942. Speaker: Mr. C. R. Quick, Division of Plant Disease Control, United States Department of Agriculture. Subject: Certain methods of forcing seed germination. The speaker presented a classification of the difficulties which may be encountered in the germination of seeds, and discussed methods of obviating the several types of difficulties enumerated. Data representing the successful growth of hard-to-germinate seeds were presented on lantern slides. About 25 members and friends of the Society attended. C. R. Quick, Secretary.

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Contents

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THE GENETIC APPROACH TO PROBLEMS OF RARE AND ENDEMIC SPECIES

G. Ledyard Stebbins, Jr.

One of the questions that every field botanist with an inquiring mind is bound to ask is: Why are some plant species widespread and common, while others are rare and local? The problem of rare species has a twofold fascination; their discovery never fails to provide a thrill, while the analysis of their affinities and distribution often gives valuable clues to the history of floras. It is natural, therefore, that many botanists have given their answer to this question, and that these answers have been as diverse as are the minds of their proponents. Among these answers there have recently appeared a series which has emphasized the genetic constitution of the species involved. The object of the present article is to review the available evidence upon which these concepts are based, to suggest ways in which new experimental evidence for them may be obtained, and to follow out some of their implications when applied to problems of the history of floras and plant evolution.

The word "rare" may not always mean the same thing. Some plants are regarded as rare because throughout a large part of their range they are found only as scattered individuals or small groups, separated by miles from their nearest neighbors. Such is the case with many species of orchids, such as *Calypso bulbosa* (L.) Oakes, *Cephalanthera Austinae* (Gray) Hel., *Cypripedium arietinum* R. Br. and *Aplectrum hyemale* (Muhl.) Torr. In most of these cases, however, there are some regions where the species concerned are abundant. *Calypso,* for instance, is common enough in the northern Rocky Mountains, as is *Cypripedium arietinum* in parts of southern Ontario, while the rarity of *Aplectrum* is due largely to extermination by man. Another type of rarity is extreme localization. A species may occur in only a few widely separated localities, but may be abundant enough where it is found. This is notably true of *Phyllitis Scolopendrium* (L.) Newm. var. *americana* Fernald, the hart's tongue fern in eastern North America. Many species of serpentine barrens in California, such as *Cupressus* spp. and *Streptanthus* spp. are similarly distributed. Still a third type of rareness is extreme endemism. A species may occur only in one or two spots on the entire globe, but in this case it is almost always represented in these spots by hundreds of individuals. These three types are, of course, connected by innumerable intermediate cases. In the writer's opinion, the concepts set forth below will apply with modifications to all of them.

As a necessary background for this study, let us review briefly the most widely current answers to this question of why certain

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species are rare. Perhaps the most direct and simple answer is that of Willis (34, 35), who maintains that in general rare and endemic species are beginners, which have not yet had time to spread. The weaknesses and fallacies of this hypothesis have been fully exposed by Fernald (16), Wright (38), and Hubbs (23), so that they need not be dwelt upon here. It will be pointed out below that our present concepts of the genetic structure of species, which have been developed as a result of many painstaking experiments, throw into glaring relief the fallacies of Willis's reasoning. In addition, recent paleobotanical research has added greatly to the number of rare modern species whose fossil ancestors are known to have been common and widespread, and this is particularly true of the endemics of the California flora (Chaney, 7, Axelrod 2, 3).

A second answer was given by Fernald (15, 17, 18), as a result of his keen observations in the field and his careful analysis of the distribution of many rare species in the flora of eastern North America. This is the concept of senescence; that most rare species were once common, but that their great age and the vicissitudes to which they have been subjected have made them "conservatives," and unable to spread. This concept, based as it is upon extensive observations of rare plants as they actually grow in the field, has much to recommend it. Most field botanists will agree with Professor Fernald that conservatism rather than aggressiveness is characteristic of rare plants. In fact, the genetic concept to be reviewed below is based primarily upon this assumption. The weakness, however, of the concept of senescence is the implication that conservatism results directly from the age of a species. There are two large objections to this implication. In the first place a number of species, such as *Sassafras variifolium* (Salisb.) Ktze. *Liquidambar styraciflua* L. and *Ulmus americana* L. are known to have close relatives that go far back into the fossil record, and yet the present species are still widespread and common, having invaded much of the region that was covered by the Pleistocene ice sheet. The other, and perhaps more serious objection is that the same species may be rare and conservative in one part of its range and common and aggressive in another. *Erigeron compositus* Pursh is cited by Fernald (15) as one of the "senescent" species composing the relict flora of the Gaspé Peninsula. In the Sierra Nevada of California, and presumably also in the Rocky Mountains, this species is far from conservative. The variety of habitats which it occupies is matched by the morphological variability of the species itself. *Adenocaulon bicolor* Hook. was considered a "senescent" species (Fernald 18) on the basis of the disrupted range and obvious great age of the genus and the rarity of *A. bicolor* in the Great Lakes region. In California this species grows under redwoods, as Fernald has pointed out, but it is also common under *Pseudotsuga, Abies, Pinus ponderosa* and other conifers. In the Sierra

Nevada at middle altitudes, however, *Adenocaulon* is far from conservative. It is one of the commonest and most aggressive weeds about cabins, being often the first species to occupy disturbed ground, if sufficiently shaded. From the hypothesis of senescence one would be forced to conclude that *Erigeron compositus, Adenocaulon bicolor,* and similar species are old in the east and young in the west. This conclusion seems illogical in the extreme. And in one genus, *Antennaria,* there is direct evidence that the conservative, "senescent" species of the Gulf of St. Lawrence area are actually younger than their common, widespread western relatives. With one exception these Gaspé and Newfoundland antennarias are exclusively apomictic; staminate plants are unknown in them. They therefore are "dead ends" from an evolutionary point of view, and must have originated from sexually reproducing species (cf. Stebbins, 29). Their only close sexual relatives, and therefore their presumable ancestors (*A. umbrinella* Rydb., *A. microphylla* Rydb., *A. reflexa* Nels., *A. media* Greene, *A. monocephala* T. & G., etc.) all occur in western North America, and are for the most part widespread, common, and aggressive enough to have colonized extensively areas vacated by the Pleistocene glaciers. Therefore, the conservatism of the relict *Antennaria* species cannot be due to age alone, since their ancestors have still retained "youthful" characteristics.

The third answer to this problem of rare species is the genetic concept which is to be reviewed in the present paper. It is based upon the realization, as a result of the experiments of Turesson and others (cf. Turesson, 31; Hiesey, 22; Clausen, Keck and Hiesey, 8), that most widespread and common plant species consist of a large number of genetically different biotypes, many of which differ widely in their ecological preferences. This is, of course, the basis of the ecotype concept, which conceives of these widespread species as consisting of several clusters of similar biotypes, each cluster, or ecotype differing from other ecotypes in its ecological preferences. On the basis of this concept, the range of ecological tolerance of a species, in the sense of Good (20), embraces the tolerance ranges of all of its component ecotypes and biotypes. Naturally, therefore, a species with many ecotypes and biotypes will be widespread and common. And conversely, a species which is poor in biotypes, and has only one ecotype, will be rare, unless its individual biotypes have a wide range of ecological tolerance, or unless the particular conditions to which they are adapted are widespread. A rare species, therefore, may be conceived of in genetic terms as one poor in biotypes, and with its biotypes so specialized that they can grow and compete with other species in only a limited area. Aggressiveness, or the ability of a species to colonize new areas, and to crowd out other species, is the result of the possession of a great store of genetic variability either evident or concealed. This consists of genetic heterozygosity, of biotypes preadapted to new conditions

which the species might encounter, or of a rapid mutation rate, by which new biotypes may be produced. A species is conservative, on the other hand, if it contains few biotypes, most of which are homozygous or nearly so, and has a low mutation rate.

This concept was foreshadowed by Darwin's classic statement that "wide ranging, much diffused, and common species, vary most." It was hinted at some time ago by Turesson (31), but so far as this writer is aware was first clearly stated by Anderson (1, p. 496). Hultén (24) made it the cornerstone of his brilliant analysis of the history of the Arctic flora, while Camp (6) used it to explain the relative constancy and limited distribution of some species of the interesting genus *Befaria*. Cain (5) pointed out the advantages of this concept over that of senescence, while Raup (28) recognized it as an important factor in the distribution of species of boreal America. Fassett (14) made the determination of genetic constancy in certain areas a major objective of his interesting and valuable study of variation in *Rubus parviflorus*.

The main difference between this genetic concept and that of senescence is that it aims to interpret the rarity of species primarily as a result of their present constitution, without implying anything about the past history or future fate of the species concerned. Many, and perhaps most rare species were once more common and aggressive, but not all. The phenomenon of insular species, many of which have always been rare, will be discussed below. The rare conservative species which were once common have been characterized by Turesson (31) and Hultén (24) as having been "depauperated with regard to their biotype contents" (Turesson 31, p. 97). Since the word depauperate is generally applied to plants of small size, its use in the present sense seems inadvisable. The word depleted expresses the situation more precisely and has no other connotation. To those who accept this genetic hypothesis, therefore, the writer suggests that the term "depleted" be used for those rare, conservative species which appear to have been formerly more common and aggressive; i.e., the "senescent" species of other authors.

Griggs (21) has recently sought to explain the rarity of plant species on the basis of competition. He states that (p. 592) "a species is rare because it cannot compete successfully with the common plants," and that "most rare species find their habitats in the early stages of the ecological succession." These statements are supported by a wealth of evidence derived from a study of rare plants in eastern North America. They lead to a conclusion similar to that implied by the term senescence, namely that those rare species which have ranges at present disrupted, but formerly continuous, "are therefore slowly dying out." On the basis of this hypothesis Griggs admittedly has difficulty in explaining the fact that many of the plants which are rare in eastern North America are common in the west. And if one examines the plants which are rare in western America, particularly those of

California, one finds that Griggs' hypothesis does not apply to a large number of them. The most famous rare species in California is the big tree, *Sequoiadendron giganteum* (Lindl.) Buchholz. Others, almost equally famous to botanists, are *Cupressus macrocarpa, Pinus Torreyana* Parry and *P. radiata* Don, *Picea Breweriana* Wats., *Abies venusta* (Dougl.) Koch, *Quercus Sadleriana* R. Br., *Crossosoma californicum* Nutt. and *Lyonothamnus floribundus* Gray. None of these species can be said to "find their habitats in the early stages of ecological succession." They are sub-climax, climax, or post-climax types. Furthermore, such observations as have been made indicate that in restricted areas and under certain conditions these species can compete very well with their common associates. Mr. Woodbridge Metcalf of the Division of Forestry, University of California (unpubl. bulletins and oral comm.), has found that seedlings of the big-tree may under certain conditions become established in great numbers. Once established, they grow very rapidly and in one forest, started through natural reseeding in the early eighties, "none of the associated species have been able to keep pace with the sequoias in height, though there are some excellent specimens of sugar pine, *Pinus Lambertiana,* and white fir, *Abies concolor,* in situations where they have not been too much crowded by the big-trees." Apparently the limits to the spread of this most famous of rare plants, are the specialized conditions necessary for the successful establishment of seedlings. These are chiefly a disturbed mineral soil, and a sufficiently early onset of the fall rains during the early years of growth. In these respects the seedlings of the common species of Sierran trees are much less particular. Another rare Californian, *Pinus radiata,* the Monterey pine, is a very good competitor in the regions where it grows naturally. Last spring the writer led a class through a clearing in a grove at the northernmost of its three natural localities, Ano Nuevo Point. Although this clearing had gone over completely to grassland (the predominant plant formation for miles along the coast both north and south of the four mile stretch of pine forest) it was filled with vigorously growing pine seedlings, which will soon crowd out the grass, and restore the area to its natural cover of pines. Furthermore, there were abundant seedlings of *P. radiata* throughout the stand, and in some places beyond its edges, so that one could not possibly draw the inference that the species is dying out. Mr. H. A. Jensen, of the California Forest Experiment Station has informed the writer that the southernmost grove of *P. radiata,* at Cambria, was once extensively lumbered, and has since restored itself. Hence neither the statement that rare species occupy chiefly pioneer habitats nor that they are slowly dying out applies to the most famous of Californian rarities.

Griggs' hypothesis, however, still is of great value in interpreting many of the rare plants of eastern North America. Furthermore his emphasis upon ability to compete as a major

factor in the distribution of both rare and common plants is fully justified and is an important part of the concept of genetic homogeneity as here presented. This seems evident from the writer's preliminary observations of one of the most interesting endemics of the San Francisco Bay region, *Dirca occidentalis* Gray. This species is restricted to an area about ninety miles long and twelve miles broad, being most abundant in the Oakland and Berkeley hills. Its nearest relative, which it resembles rather closely, is the wide-spread eastern American *D. palustris* L. (fig. 1). In contrast to the swamp habitat of the eastern species, *D. occidentalis* occurs principally upon well-drained hill slopes, where its chief competitors are other shrubs, such as *Toxicodendron diversilobum*

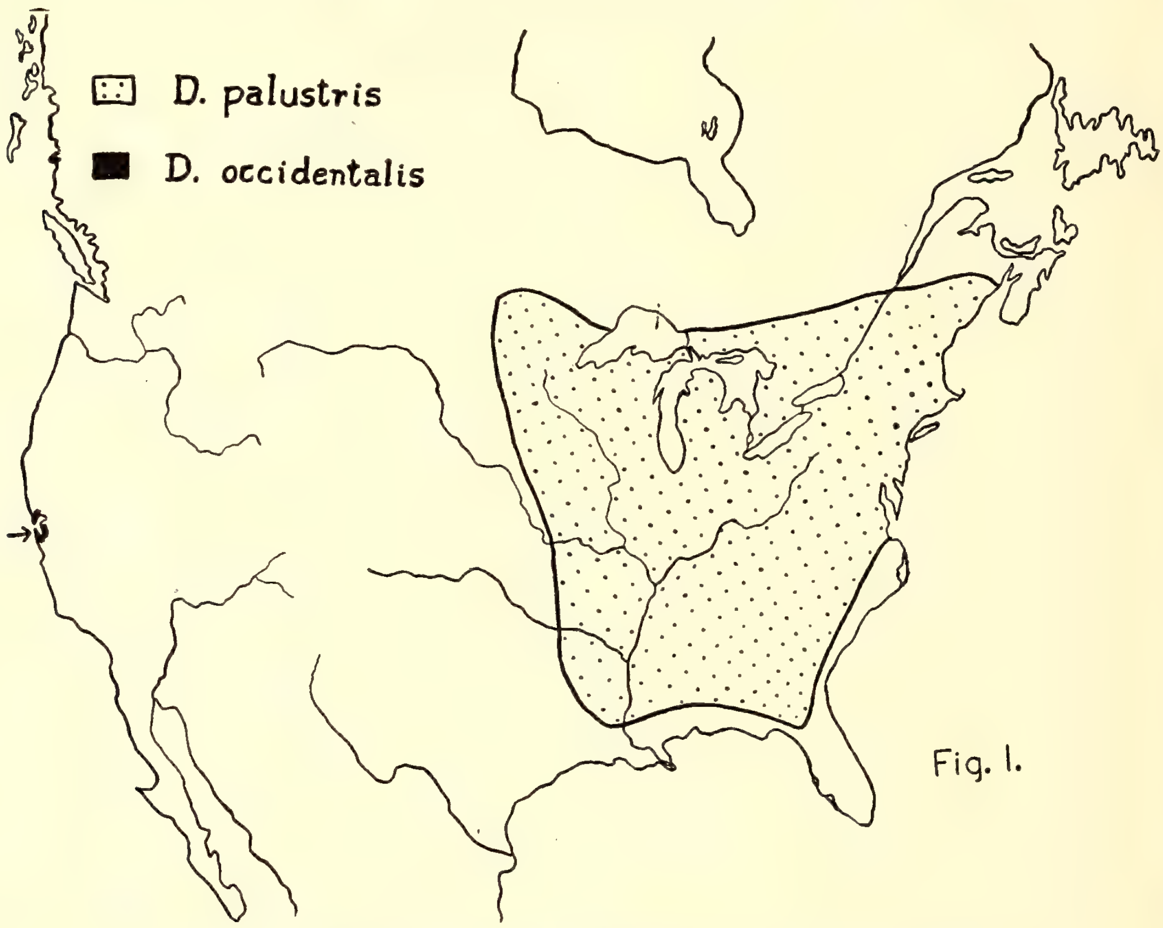

Fig. 1. Ranges of *Dirca palustris* and *D. occidentalis.*

(T. & G.) Greene, *Baccharis pilularis* DC., *Rhamnus californica* Esch., and *Osmaronia cerasiformis* (T. & G.) Greene. In Wildcat Canyon, just east of Berkeley and still within the summer fog belt, *Dirca* is rather common, and in a few places forms almost pure stands. Here the writer has observed several clearings in sheltered north and east facing slopes, where *Dirca* seedlings were more abundant than those of any other shrubs, and were competing on equal terms with *Toxicodendron,* and doing better than *Baccharis* or *Rhamnus.* On such slopes young *Dirca* seedlings can be found everywhere under the other shrubs, so that there seems no more reason to suppose that it is dying out than that *Rhamnus, Osmaronia,* or *Symphoricarpus albus* are disappearing from this

area. On the sunnier west and south facing slopes, however, adult *Dirca* shrubs are sometimes found, but no seedlings have been observed. *Toxicodendron* and *Baccharis,* on the other hand, are equally vigorous and self-perpetuating in both sites. If one travels two miles east from Wildcat Canyon, crossing a ridge 1500–2000 feet high, one reaches the inner edge of the fog belt, where the summer weather is considerably drier and hotter. Here *Dirca* is rather local, and occurs only in shade. The only extensive stand seen by the writer was in dense shade under a grove of live oaks (*Quercus agrifolia* Nee), a habitat which it never occupies in Wildcat Canyon. Here it was accompanied, as usual,

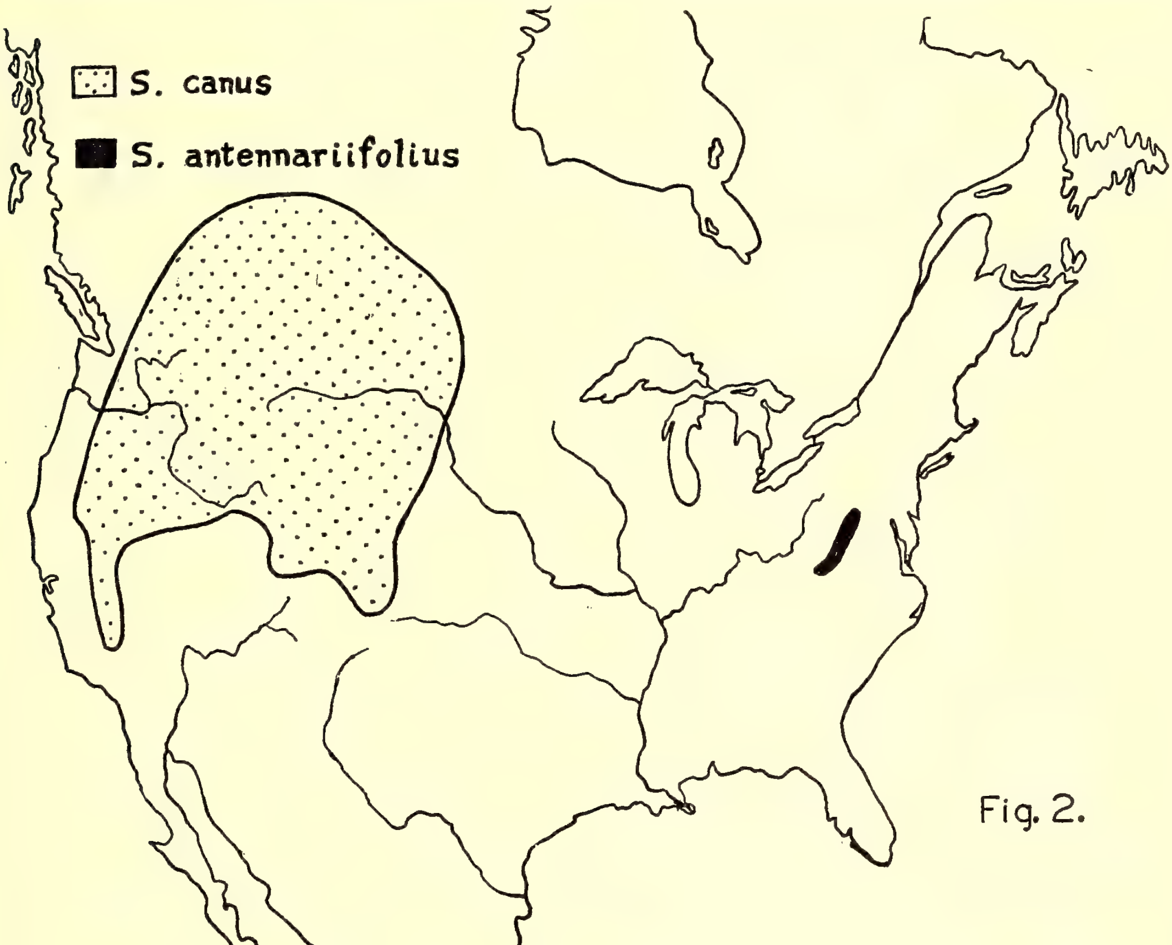

Fig. 2.

FIG. 2. Ranges (generalized) of *Senecio canus* (*sens. lat.*) and *S. antennariifolius.*

by poison oak (*Toxicodendron*), but the latter species was also abundant on the open, sunny slopes away from the oaks. Going eastward from Orinda, one would have to travel 1500 miles before he would see *Dirca* again. The logical inference from these observations is that *D. occidentalis* contains only a few biotypes, with a limited range of tolerance. These are successful only in sheltered spots, and may require the rather heavy type of soil characteristic of the Berkeley Hills. In the fog belt, they are only moderately tolerant of shade, while in the warmer regions east of the fog the seedlings can compete successfully only in deep shade, where they are met and surpassed by the more vigorous

competition of such undershrubs as *Rhus, Osmaronia, Symphoricarpus albus* (L.) Blake and *Corylus rostrata* Ait. var. *californica* A. DC. These more common competitors, on the other hand, appear to possess biotypes which can withstand a variety of sun and shade conditions in both Wildcat Canyon and Orinda.

The above argument may be summed up by a definition of the concept of *genetic homogeneity,* as follows. In continental areas, most rare or narrowly endemic species are genetically homogeneous, and may therefore be termed *homogenic.* They consist of relatively few biotypes which are themselves relatively homozygous. In contrast, the common and widespread species are usually heterogeneous in their genetic makeup. They include many biotypes, often grouped into more or less distinct ecotypes, and a large proportion of their individuals are genetically heterozygous, possessing a store of genetic variability beyond that which is evident from the appearance of their phenotypes.

This concept of genetic homogeneity, however plausible it may seem, is nevertheless only a working hypothesis. It should be put to the acid test of experimentation. Two lines of attack occur to the writer. In the first place, the genetic variability of typical rare species should be tested by growing under constant, controlled conditions progenies from all parts of their ranges. This variability should then be compared with that found in a series of progenies of their most common competitors, taken from various parts of the range of the rare species, as well as from beyond that range. Finally, in the case of species that are rare in one part of their range and common in another, or of those rare species that have close relatives elsewhere it should be possible to inject new variability, and therefore new aggressiveness into them by means of hybridization. In other words, if the concept of genetic homogeneity as the cause of "conservatism" is valid, wide intervarietal or interspecific crossing should replenish the biotype supply, and make for increased aggressiveness. Some of the new hybrid derivatives should then be easier to establish in new sites than the original rare species.

While recognizing that this hypothesis needs experimental confirmation, we can nevertheless follow out some of its implications. In the first place, it is entirely incompatible with the hypothesis of "Age and Area." The concept of genetic homogeneity is based partly on the assumption that in terms of the geological time-scale the migration of young species into new territory is rapid or at least fast enough to keep up pretty nearly with the prevailing rates of climatic change. The distribution of a species will be a reflection of its store of genetic variability only if each ecotype can occupy all of the contiguous territory to which it is suited in a relatively short period of time. This assumption, diametrically opposed to Age and Area, was emphasized by Gleason (19) and explains the facts of distribution as the present writer has observed them. Many species whose seeds have no

obvious means of rapid dispersal are widespread in new territory. The lupines of California are good examples. On the other hand, many species with apparently excellent means for dispersal are highly restricted. To cite just one instance, there are in California a number of native species of thistle (*Cirsium*), all with presumably equally efficient methods of seed dispersal. Some of these, *Cirsium fontinale* (Greene) Jepson, *C. campylon* Sharsmith, *C. Andrewsii* (Gray) Jepson, and *C. Vaseyi* (Gray) Jepson are more or less rare and local. One cannot ascribe this localization to the recent origin of the forms in question and the consequent lack of time for their distribution, since various European thistles, such as *Cirsium lanceolatum* (L.) Scop., *C. arvense* Scop., and *Silybum marianum* Gaertn., with apparently no better methods of seed dispersal than the native species mentioned, have become common in various parts of California within the past hundred years or less. These rare California thistles have failed to spread because they are not adapted to any of the areas adjoining their present ranges.

Furthermore, the genetic concept of intraspecific variability offers an entirely different, and in the writer's opinion more satisfactory, explanation of the facts upon which Willis has based his hypothesis. Willis's two main lines of evidence are first that endemic species are in general rarer even in the places where they occur than are widespread species in the same area, and second that the ranges of related species often overlap in "chain-mail" fashion, so that at the limits of their ranges they may intermingle with each other. The first point, which is borne out by most rare species, is entirely compatible with the concept of the genetic uniformity of rare species. These species are adapted to only a few ecological niches, and these niches are not only restricted geographically, but are in general of small extent even in the regions where they do occur. To use a simile: a physician belongs to a widespread and common profession. Not only is there room for physicians in every town in the world, but in addition a city can absorb a large number. A botanist, on the other hand, belong to a profession which is rare and local. There are only a few cities, those which possess a large institution of learning, in which a professional botanist can survive at all, and in these botanists are much rarer than physicians, because there are many fewer places which they can occupy. Similarly a plant species with a narrow range of tolerance will tend to be not only localized geographically but also rare where it does occur.

The "chain-mail" pattern of distribution can be explained equally well upon the genetic concept, without resorting to "Age and Area." Willis argues that if two related species are found together in the same forest one cannot assume that they have different ecological preferences. This may be in part true, although one cannot help remarking that every forest or meadow has inequalities, however slight, of topography, exposure, soil,

moisture, etc., which would permit individuals with unquestionably different ecological preferences to grow near each other. But even if we grant that two groups of individuals belonging to different species have the same genetically conditioned ecological requirements, we need not conclude from this fact that the two species as wholes have the same range of tolerance. The biotypes which are ecologically equivalent may represent opposite extremes of the ranges of genetic variability of the two species. The normal or average biotypes of the two species may be very different from each other. For instance, *Pinus ponderosa* (*sens. lat.*) and *P. contorta* var. *Murrayana* overlap in the Sierra Nevada in typical "chain-mail" fashion, so that forests exist where the two species grow side by side, although in general *P. ponderosa* grows at lower altitudes and in drier situations than *P. contorta* var. *Murrayana.* This overlapping may mean that the hardiest, most moisture tolerant individual biotypes of *P. ponderosa* are nearly or quite equivalent to the least hardy, most drouth resistant ones of *P. contorta* var. *Murrayana,* but it certainly does not mean that the two species as wholes are ecologically equivalent. In fact, the only reasonable conclusion which one can draw from the ranges of these two species, which occur separately over enormous stretches of territory, at very different altitudes and latitudes from each other, is that they have very different ranges of tolerance. And there is no case of "chain-mail" distribution known to the writer to which the same explanation cannot be applied.

When "Age and Area" has been eliminated, there remain two possible conditions of the past history of a rare species. One is that the species was once more common, widespread, and richer in biotypes than now, so that its present rarity is due to depletion of the store of genetic variability. The other is that the species never was common, but diverged from a small group of individuals of a widespread ancestral species, following the establishment of these individuals upon a small insular area. There are thus two types of homogenic rare species, *depleted species* and *insular species.*

The evidence from both paleontology and present distribution indicates that depleted species are frequent, and constitute a large proportion if not a majority of rare species (Fernald, 16, Axelrod, 2). The process of depletion has two stages. First, the widespread, common species becomes reduced in geographic distribution and in numbers through climatic or geological changes which eliminate many of its original habitats. During this process many biotypes and ecotypes are automatically destroyed, both through the complete elimination of the species from many areas and through more rigid selection in the few regions where it can survive. After this reduction in numbers, the species may still preserve a considerable amount of individual genetic variability, as well as a store of potential variability in

the form of recessive genes for which the individuals are heterozygous. Its continued existence as a series of small, completely isolated populations will, however, automatically lead to the further depletion of each population. As Wright (37) and Dobzhansky (12, p. 334) have pointed out, such small populations become more uniform genetically on account of inbreeding. Recessive genes tend to express themselves phenotypically, and thus become eliminated through adverse selection. Furthermore, the process known as random fixation takes place, so that purely by the vagaries of chance each population becomes uniform for a series of non-adaptive characteristics which in the larger population varied from individual to individual. This, of course, leads to the divergence of the isolated populations. It explains the fact that depleted species are usually sharply defined, that is morphologically very distinct from their nearest relatives, as well as being relatively uniform.

In addition to the depleted species, there is also a large body of rare species which have always been so because they have never had an opportunity to spread. Since such a condition is most characteristic of islands, rare species of this type can be termed *insular species* (Kinsey, 25). If through some accident a small group of individuals of a continental species becomes established upon an island, they will carry with them only a small part of the genetic variability of the original species. Furthermore, inbreeding and random fixation will tend further to make this insular population more uniform and more different from its continental ancestor as the years of its isolation progress. Thus the genetic structure of a restricted insular species becomes homogenic as does that of a depleted one.

There is, however, one way in which insular populations can maintain a certain degree of variability. If the insular areas are near enough to the continental ones or to other islands so that the migration of individuals to the island can occur repeatedly, the insular population can periodically be enriched with a new infusion of genetic variability. It becomes the semi-isolated population which, according to Wright (37), has the best potentialities for evolutionary progress. If the insular area or areas are small, the species will remain rare, but it will have an unexpected amount of variability. Thus a rare species confined to several small, insular areas partly isolated from each other is an exception to the hypothesis stated above of genetic uniformity for rare species. It has a potential aggressiveness, but cannot spread because it has no place to go.

Insular species are most easily recognized when they occur on actual islands, but they also exist within continental floras. Any species which occurs in a small area of favorable territory surrounded by extensive areas which neither it nor any of its close relatives could possibly occupy is as isolated as if it were on an island (cf. Kinsey, 25). This is true of the species of isolated

mountain tops which contain an alpine flora but are surrounded by great stretches of temperate or tropical lowland; of those found in oases in a desert, whether the oases are associated with streams, springs, or isolated mountain ranges, and of those in many types of habitats which are radically different from their surroundings.

It is on one of these terrestrial "islands" that there occurs the example best known genetically of a plant species which, though rare, has an unexpected amount of variability due to its existence in a series of semi-isolated colonies. This is *Oenothera organensis* Munz (*O. macrosiphon* Wooton & Standley) endemic to the Organ Mountains of New Mexico, which occurs in a series of small colonies along the only living streams found in this arid range of mountains completely surrounded by desert. It is a mesophyte living in the only mesophytic habitats available to it. Emerson (13) found that *O. organensis* has an unexpectedly high number of genes for self-incompatibility. Wright (36) on the basis of his mathematical deductions, could explain this situation only by assuming that the total number of about five hundred individuals found in the species was divided into a series of small, semi-isolated colonies, an assumption fully warranted by its distribution. *Oenothera organensis* may have a good deal of potential aggressiveness, which might result in a spreading of the species if an increasingly moist climate should open up new habitats to it.

In discussing the flora and fauna of actual islands, the distinction is often made between continental islands, which were formerly connected with some large land mass, and oceanic islands, which have never been so connected (Baur, 4). The flora and fauna of the former are said to be harmonious, since they are derived entirely from one continental area, while those of the latter are termed disharmonious, being derived from two or more different continental areas, and by several different migrations from each area at widely separated intervals. Terrestrial insular areas may be similarly classified as to their origin. Many, such as most of the alpine regions in mountain ranges of the north temperate zone, were once connected with extensive continental areas of similar ecological conditions; others were never so connected. The latter nearly always provide striking cases of endemism.

One such area in the eastern United States is the famous series of shale barrens in the Appalachian Mountains, extending from southern Pennsylvania to southwestern Virginia and eastern Tennessee. These barrens occur wherever rocks of certain geological formations outcrop on steep slopes. They are mildly arid as well as poor in mineral matter, so that they support a flora more xerophytic than that in the surrounding hills (Core, 11). Although each slope is obviously a pioneer habitat, destined to disappear as soil accumulates on it, new barrens are constantly being created by weathering and stream erosion, so that the shale barren habitat has probably existed continuously ever since the

uplift of the Appalachians began early in the Tertiary period, and will continue to exist as long as these mountains stand. They thus represent, like the seashore, a "pioneer" habitat of permanent duration, at least so far as present-day species are concerned. Although the climate of the Appalachian region may at times have been drier than it is now (Gleason, 19, Core, 10), there is no reason to believe that it was ever arid or even semi-arid, so that the possibility that the shale barrens were ever joined to the large semi-arid areas in the central and western United States by a continuous stretch of territory similar to the present barrens is rather remote. Hence they represent semi-xerophytic islands in a region dominated by a mesophytic forest. The flora of these shale barrens, as analyzed by Wherry (32, 33), contains species of rather diverse affinities. Some like *Senecio antennariifolius* Britton, are closely related to xerophytic western species. Others, like *Oenothera argillicola* Mackenzie, show certain characteristics in common with western species, but no close relationship. Cleland (9) has pointed out that *O. argillicola* resembles the western *O. Hookeri* alliance in its large flowers, self-incompatibility, and in forming pairs of chromosomes rather than rings at meiosis. In other morphological characteristics, however, it is more like some of the eastern species, and the arrangement of its chromosome segments is somewhat different from that of any other species. Still other shale-barren species, like *Pseudotaenidia montana* Mackenzie, are of very obscure affinities. Finally there is a series of shale barren species which have obviously evolved from mesophytes of the surrounding flora. Some of them are specifically different from their mesophytic relatives, others are apparently only ecotypes, while still others are of doubtful status. In view of this diversity of affinities, the hypothesis of Wherry (32, 33) that all of the shale barren plants originated somewhere to the northwest, seems unlikely. The plant association of these barrens appears rather to have been gradually built up over a long period of time through the addition at widely separated intervals of plants derived from very different sources.

In the west, such permanently isolated areas are more common. The mountain ranges of the southern Great Basin are excellent examples. They were uplifted during the latter part of the Tertiary period (Louderback, 26), and it is very unlikely that the forest and alpine areas of their higher slopes were ever continuous with those of other mountains. The best known of them floristically is the Charleston Range of southern Nevada. The enthusiastic and thorough explorations of Mr. Ira W. Clokey have uncovered a large number of endemic species of diverse affinities, and the high montane flora as a whole differs from all others in the world.

Another series of examples on a much smaller scale are the serpentine barrens of central California. Species of certain genera, like *Streptanthus,* will grow in this region only on serpen-

tine, so that these barrens for them are and probably have always been islands. Some of these *Streptanthus* species are endemic to only one or two barrens (Morrison, 27). These have probably always been rare, and may have been derived rather recently from the more widespread species by the establishment and divergence of an insular population as described above. So far as the writer is aware, no study of the geographic affinities of the serpentine barren endemics has been attempted; on the basis of the present discussion, these affinities should be diverse.

Not all species now endemic to islands are insular in the sense that their present population has been derived from a few individuals of an existing continental species. Relict, depleted species have been preserved on many islands, as well as on terrestrial insular areas (Baur, 4). This is particularly true of islands of continental derivation, and may be due to the lower intensity of competition as compared with continental areas. The Channel Islands off the coast of southern California, for instance, have preserved the last remnants of such species as *Lyonothamnus floribundus* Gray, *Prunus Lyoni* (Eastw.) Sarg. and *Quercus tomentella* Engelm., which are known through fossil evidence to have been formerly more widespread, and very likely consisted of several ecotypes (Axelrod, 2, 3). Even on oceanic islands or those with remote continental connections there are often found species which are apparently either the last relics or the immediate derivatives of ancient genera now extinct elsewhere. This is well illustrated by some of the arboreal Compositae of the Pacific Basin. Two of the archipelagoes west of South America, namely Juan Fernandez and the islands of San Felix and San Ambrosio contain endemic genera of the tribe Cichorieae; *Dendroseris* on Juan Fernandez and *Thamnoseris* on San Felix and San Ambrosio, which are related neither to each other nor to any other genus found in the Southern Hemisphere. *Thamnoseris* appears to be nearest to *Stephanomeria* of western North America, particularly *S. Blairii* Munz & Johnston, an anomalous endemic of San Clemente, one of the Channel Islands. *Dendroseris* is of more obscure affinities but is also most nearly related to North American genera. The modern species of both *Thamnoseris* and *Dendroseris* therefore, must have had more widespread ancestors, and are to be considered as relict, depleted genera. Another case is *Hesperomannia*, endemic to Hawaii, where it is very rare. Its nearest relatives are *Augusta* (*Stifftia*) of Brazil and *Nouelia* of southwestern China. All three are apparently the last remnants of a group which must have been widespread in the Northern Hemisphere in Cretaceous or early Tertiary time (Stebbins 30). *Fitchia*, endemic to two islands of Polynesia, is an extraordinary genus which combines the characteristics of the tribes Mutiseae, Heliantheae, and Cichorieae, but has no close relatives in any of them. It is obviously a relict genus, perhaps a survivor of an ancient stock of

Compositae which existed before the present tribes became differentiated from each other.

Since both insular and depleted species may occur on insular areas, terrestrial as well as actual islands, the differentiation between the two types in such areas is a difficult problem. No set rule will hold for all species, but two criteria can be considered as valuable. First, if the endemic is closely related to a widespread species which occurs on an adjacent continental area, it is probably a strictly insular species, while if it is closely related to no other living form, or has its relatives in some remote corner of the globe, it is more likely a depleted species or a derivative of one. Second, if the endemic is morphologically a highly specialized type in relation to its continental relatives, it is probably an insular descendant of these; while if it is less specialized it may be their depleted ancestor.

Finally we must consider the future of these homogenic rare species. The most obvious fact is that they are more at the mercy of climatic changes than are the common, variable species. Just as their genetic rigidity prevents them from occupying new habitats, so it must also reduce their power to adapt themselves to climatic changes. Hence if the climate remains the same they may persist as rare species indefinitely. If it becomes more unfavorable to them, they are likely to disappear. This is the fate awaiting many Californian trees and shrubs, notably *Pinus Torreyana, P. radiata, Abies venusta* and *Cupressus macrocarpa,* if the progressive desiccation of our climate continues. On the other hand, if conditions become more favorable for the spread of their few remaining biotypes, they may become more common. Then, if two or more isolated colonies of a depleted species are enabled to spread until they meet, a partial replenishment of the store of genetic variability may take place. During their isolation the disjunct colonies must have acquired some different genetic characteristics, both by mutation and by random fixation (Wright, 37, Dobzhansky, 12). Thus when two such colonies reunite, hybridization between genetically different individuals is made possible. By this means, a large number of new genetic combinations may arise, replenishing the store of genetic variability, and opening up new possibilities for the spread of the species.

Examples of species that have apparently been replenished in this fashion are provided by relatively widespread and common members of mono- or ditypic genera which occur in the same region and appear to be somewhat related to each other, but are very sharply set off morphologically and have no close interrelationships. Such a group is found among the Compositae, tribe Cichorieae of the Sonoran desert of western North America. Here there are two monotypic genera, *Anisocoma* and *Atrichoseris,* and three ditypic ones, *Rafinesquia, Calycoseris,* and *Glyptopleura.* These are all related to each other and to the larger genera *Stephanomeria* and *Malacothrix.* Together with *Pinaropappus* of

Texas and Mexico as well as the insular *Thamnoseris* mentioned above, they form a natural group, not closely related to any other Cichorieae. The small size and remarkable distinctness of the genera and most of the species of this group is in sharp contrast to the situation in the Cichorieae of the Old World, where most of the genera are relatively large and are so closely interrelated that generic boundaries are very difficult to define. Supposing, however, one were to select a dozen species from each of the large Old World genera *Lactuca* and *Crepis,* and one or two each of *Hypochaeris, Leontodon, Sonchus, Launea, Ixeris,* and *Youngia,* choosing the more xerophytic members of each genus and should then deposit these species upon a semi-arid or desert area completely devoid of Cichorieae, and they all became established in this area, the resultant pattern of variation would closely simulate that now found in the western American Cichorieae mentioned above. This suggests the hypothesis that exactly such a process of selection has taken place in the history of the latter. Their history may have been somewhat as follows. Once the entire group consisted of a few fairly large closely interrelated genera, or of one genus divided into several sections. Then the group became much reduced in numbers, due to the reduction in extent of the habitats which it occupied, and was broken up into many partly or completely isolated populations. The larger of these retained their store of genetic variability throughout the period of reduction. The smaller ones, being subject to intense selection and random fixation diverged sharply from the ancestral stock, and at the same time became much depleted genetically. Then with the restoration of conditions favorable to the group, all of the remaining species were able to spread again. Those less completely isolated then gave rise to the more closely interrelated species of the larger genera *Stephanomeria* and *Malacothrix,* while the descendants of the strongly isolated and depleted small populations became the distinctive mono- and ditypic genera. This history may be greatly oversimplified; perhaps several cycles of depletion and replenishment were necessary to produce the pattern of variation found in this group. Nevertheless, the occurrence of such cycles in the evolutionary history of this and other groups is a very likely possibility, and may have been of considerable importance in the differentiation of species and genera throughout the plant kingdom.

The writer is much indebted to Dr. Daniel Axelrod, Dr. Lincoln Constance, Dr. Carl Epling, and Dr. Herbert L. Mason for helpful advice and criticism.

Summary

The concept of age and area and that of senescence of species in the stricter sense is not considered adequate to explain the occurrence of rare and endemic species. Instead the writer regards as most important the concept of genetic homogeneity.

This assumes that most common and widespread species are genetically diverse, while rare and endemic ones contain relatively little genetic variability, that is relatively few biotypes. They are therefore termed homogenic. This homogeneity reduces the number of ecological niches in which the rare species can compete successfully with other species, but if the climate is a stable one, does not necessarily cause their extinction. From the historical point of view there are two types of homogenic species. Depleted species are those which formerly were widespread and genetically diverse, but have lost many or most of their biotypes. A species may become depleted in only one part of its range, remaining common and variable in another. Insular species are those which have developed on an island or an isolated ecological habitat on a continent. They have originated from a few individuals or a single individual of the ancestral species, and have never possessed great genetic variability. The distinction between depleted and insular species is often hard to recognize, because depleted species often find their last refuges in insular areas. The future of rare, homogenic species depends upon the future of the ecological niches to which they are adapted. If the environment remains stable, they can persist indefinitely as rare species. If changes occur which obliterate their restricted habitats, they will become extinct. If, however, environmental changes result in an increase of the particular ecological conditions to which the species is adapted, it can spread. Then if this spreading permits the coming together of two isolated colonies of a homogenic species or of two such species which are still capable of interchanging genes, the populations thus united will both acquire new genetic variability. By this means a homogenic species may become diverse and widespread. If it is a depleted species, part or all of its original diversity may be restored.

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February, 1942.

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THE TYPE OF CLEMATIS HIRSUTISSIMA

Ralph O. Erickson

Clematis hirsutissima was described by Pursh on the basis of material collected on the Lewis and Clark Expedition of 1804–1806. Pursh's description is adequate and unmistakably refers to a *Clematis,* but in his comment on the species he points out that "it very much resembles [*Anemone Pulsatilla*] in several respects," and expresses the opinion that "all the division of *Anemones* with caudated seeds . . . belong to this genus [*Clematis*], or at least to one separate from *Anemone.*" Later Pursh mistakenly applied his name *C. hirsutissima* to specimens of an *Anemone* collected by Nuttall (Jour. Acad. Nat. Sci. Phila. 5: 159. 1825). Pursh's contemporaries were not willing to place the "*Anemones* with caudated seeds" in the genus *Clematis,* but rather assumed that his *C. hirsutissima* was an *Anemone,* and this was the traditional view until Meehan in 1896 discovered duplicates of most of the Lewis and Clark plants in Philadelphia. In the meantime, *C. Douglasii* Hooker had been published with a long description and a plate, and this name was generally accepted for the western *Clematis.*

Meehan (Proc. Acad. Nat. Sci. Phila. 50: 12–49. 1898) lists the specimen of *C. hirsutissima* under *C. Douglasii* with the notation, "[No label; a single flower, but well identifiable]." Further on he lists another specimen with the comment, "[Composite? Poor, sterile, and not placed; leaves opposite, much divided into narrow segments, very pubescent]. One of the most common plants of the plains of Columbia. May 27, 1806."

During a recent visit to the herbarium of the Academy of Natural Sciences of Philadelphia, the writer found the "single flower" of *C. hirsutissima* mounted on a sheet with the following note by Meehan, "Clematis Douglasii H. no ticket with the specimen probably Kooskooskee. It has been collected on the Clearwater by Spalding." Attached to this sheet with a paper clip was a second sheet bearing the specimen which Meehan had labelled, "Compositae?", and a label in Pursh's hand, "One of the most common plants of the plains of Columbia. May 27, 1806." It was obvious at once that both were *C. hirsutissima,* and careful examination of the broken ends of the peduncle showed that they could be fitted together exactly. Credit for associating these two fragments apparently belongs to Rydberg and to Piper, since the "Compositae?" sheet bore the annotations, "Clematis Douglasii? P. A. R. 1905," and (apparently later) "certainly C. Douglasii C. V. P." They have now been remounted on a single sheet.

It is now possible not only to settle once and for all the status of Pursh's name *C. hirsutissima,* but to establish the type locality more accurately. On May 27, 1806, Lewis and Clark were at "Camp Chopunnish," which was "in Shoshone Co., across the river from, and nearly opposite, . . . present Kamai or Kamiah,

in Nez Percés Co., Ida." (Coues, Proc. Acad. Nat. Sci. Phila. 50: 293 & 306. 1898). From a study of the Lewis and Clark journal for that day, it is possible to say only that the plant could not have been collected at any great distance from the camp.

Appended is a portion of the pertinent synonymy:

CLEMATIS HIRSUTISSIMA Pursh, Fl. Am. Sept. 2: 385. 1814. *Clematis Douglasii* Hook. Fl. Bor. Am. 1: 1, pl. 1. 1829.

ANEMONE NUTTALLIANA DC. Syst. 1: 193. 1818. *A. patens* var. *hirsutissima* Hitchcock, Trans. Acad. Sci. St. Louis 5: 482. 1891. *Pulsatilla hirsutissima* Britt. Ann. N. Y. Acad. Sci. 6: 217. 1891. *Anemone hirsutissima* MacMillan, Metasp. Minn. Valley, 239. 1892.

Missouri Botanical Garden,
St. Louis, Missouri,
April 6, 1942.

FRANCIS RAMALEY

Francis Ramaley,[1] for forty years head of the Department of Biology of the University of Colorado and professor emeritus since 1939, died June 10, 1942. He was born in St. Paul, Minnesota, November 16, 1870. The University of Minnesota granted him his bachelor's and master's degrees in 1895 and 1896. He served as instructor in botany there for three years and then came to the University of Colorado in 1898 as assistant professor of biology. The following year, after receiving the degree of doctor of philosophy from Minnesota, he became professor and head of the Department of Biology at Colorado; from this time until his retirement, the untiring devotion and wise guidance which he gave the department as well as his insistence upon high standards were factors largely responsible for its growth and high reputation.

In 1904 Professor Ramaley made a trip around the world, spending several months in study at botanical gardens at Buitenzorg, Java, and Peradenyia, Ceylon; he also visited the gardens at Tokyo, Japan. This year of travel and study stimulated his natural interest in economic botany and resulted in valuable collections for the University Herbarium and Museum.

In addition to his heavy teaching load and administrative duties, Professor Ramaley served the University in many other ways. He was acting president in 1902, acting dean of the College of Pharmacy from 1917 to 1919, and acting dean of the Graduate School in 1929 and again from 1932 to 1934. Because of his sound judgment and clear insight, he was a valuable member of many important University committees. In line with his policy of encouraging high standards of scholarship, he aided in the organization of chapters of Phi Beta Kappa and Sigma Xi, while the University was still young. From the time of the establishment of the "University of Colorado Studies" in 1902, he was the editor, a position which he held until his death.

[1] See frontispiece.

His unfailing interest in research which continued even after the beginning of his final illness, resulted in the publication of about ninety scientific and educational papers and several books. Characterized by accuracy and clarity, his writings are interesting and intelligible to the layman as well as to the scientist. His publications give evidence of his broad interests which included not only his special field of botany, but human heredity and hygiene as well. While his earlier botanical papers indicated an interest in seedling anatomy, his most outstanding work was in the field of plant ecology. As early as 1899 he introduced a course in ecology at the University of Colorado. In 1940 when he was honored by being selected to give the annual research lecture at the University, it was natural and fitting that he should select as his subject "The Growth of a Science" in which he traced the history of ecology from the time of Aristotle to the present. This address which was printed in the "University of Colorado Studies" is of interest to all ecologists.

The University of Colorado Mountain Laboratory at Tolland, Colorado, was established by Professor Ramaley in 1909; for the following ten years while he served as director of this successful mountain laboratory, he published many ecological papers dealing with zonation, succession, and the distribution of plant communities in the montane and sub-alpine zones of this section of the Colorado Rockies. He first became interested in sand-hill vegetation while he was on the summer faculty of the University of California in 1917. After he returned home he began to study similar areas in Colorado. As a result of extensive field studies pursued over a number of years, a paper entitled "Sand-hill Vegetation of Northeastern Colorado" was published in "Ecological Monographs" in 1939. His last work, "Vegetation of the San Luis Valley in Southern Colorado," which was published in March of this year, is an extensive and important contribution based on numerous field trips taken to this interesting region at different seasons during the past fourteen years. His interest in physiological ecology was indicated by experimental work involving over one hundred species of plants which were supplied with supplemental artificial light. Two published bibliographies of day length and artificial illumination as affecting growth of seed plants and three other papers constitute his contributions to this field. "Plants Useful to Man" (with W. W. Robbins) and "Colorado Plant Life" are perhaps his best-known books. In the latter, which was written for the people of the state and published as part of the celebration of the Semicentennial of the University in 1927, he presents a study of the native trees, grasses and flowering herbs. Sections of this book indicate to some extent his deep appreciation of the beauties of the world of nature which, as he tells us in the preface, he learned to know and enjoy when as a child and youth he accompanied his father through woodland and over prairie in his native Minnesota.

The ninety-eight titles listed in the bibliography do not include numerous book reviews which appeared from time to time in "Ecology," "Science," "Torreya," "Botanical Gazette," and "American Journal of Botany"; articles in the "Biology News-Letter of the University of Colorado"; nor many abstracts which were published in the "Journal of the Colorado-Wyoming Academy of Science." During the past five years he learned to read Italian and since 1939 he has prepared approximately one hundred abstracts of articles from Italian botanical journals for publication in "Biological Abstracts."

A rare faculty for presenting material in a clear, forceful manner as well as the ability to summarize and emphasize important principles combined to make Professor Ramaley an outstanding teacher and lecturer. His interest in teaching is indicated by some ten publications dealing with the teaching of science or with some other phase of education. He believed that undergraduates should be given a liberal training without too much stress on their major field. As a member of the Council on Honors at the University and as its chairman at the time of his retirement, he urged students not to neglect broad fundamentals. He believed "that the specialist with a wide background of scientific knowledge will achieve the most." His own broad knowledge of the biological sciences and related fields enhanced the value of his instruction. While he expected his students to maintain high standards of accomplishment, his dealings with them were characterized by a kindly spirit of helpfulness, genuine interest in their progress and an unusual sense of fairness. Graduate students particularly prized his constructive criticism, his inspiring standards of thoroughness and accuracy, his unfailing patience and the generous giving of his time to their problems. They, as well as his colleagues, valued him as a counselor and a friend and admired his progressive and tolerant spirit, his unassuming modesty, and his thoughtful consideration of others.

Professor Ramaley was an active member of many scientific societies including the Botanical Society of America, American Society of Naturalists, Limnological Society, Society for Experimental Biology and Medicine, Colorado-Wyoming Academy of Science, and American Association for the Advancement of Science, serving as president of the Southwestern Division in 1930. He was a charter member of the Ecological Society of America, a group which elected him vice-president in 1931, and nine years later, president and botanical editor of "Ecology."

In Professor Ramaley were combined the qualities of an eminent scientist with those of an outstanding teacher and executive; above all, he was a tolerant and understanding friend. He is survived by his wife, Ethel Jackson Ramaley, and by four sons—Edward J., David, John D., and Francis.—EDNA LOUISE JOHNSON, University of Colorado.

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REVIEW

The Flowering Plants and Ferns of Arizona. By Thomas H. Kearney and Robert H. Peebles. United States Government Printing Office, Washington, D. C. 1942. $2.00.

The flora of Arizona was studied with great interest and effectiveness by Asa Gray, John Torrey, Sereno Watson, and George Engelmann, and the half-century- and century-old papers and reports of this group of great systematic botanists have been the most useful works for general identification of plants from all but certain segments of the State.

"The Flowering Plants and Ferns of Arizona" fills a demand of long standing for an up-to-date, comprehensive study of the flora of Arizona as a unit. The book is based upon a sound piece of research, and it is particularly valuable for inclusion and evaluation of the numerous papers on special groups published prior to the time the book went to press in 1940 and for its references to these papers. This manual should serve as the foundation and

the stimulus for further study of a flora of unusual interest investigated so far only by travellers and a handful of resident botanists and by no means thoroughly known. The long experience of the authors in Arizona makes their work carry unusual authority, and the combination of this field experience with carefully considered organization of taxonomic units is a happy one. Treatment of particular families or genera by twenty-two specialists adds much to the value of the book, although, as is inevitable in such cases, it introduces some variation in the weight accorded taxonomic categories, such as genera, species, and varieties. A section of the introduction entitled "The Vegetation of Arizona" by Forrest Shreve summarizes the results of long and intensive study of the Arizona flora by one of its most critical and thorough students.

Valid criticisms of this book are few and minor. Division of the index into two parts, one for popular and one for scientific names may have some advantages, but there is a tendency to "land" in the wrong index, and a longer index including both of these would be scarcely more difficult to use for either lay or technical names. To one familiar with the excellent photography of the group at the U. S. Field Station at Sacaton and particularly with the photographs taken by Mr. Peebles, there is disappointment in some of the illustrations, although others are excellent. It is probable that the weak contrasts in some of the half-tones are to be attributed to poor reproduction of the originals.

Lack of descriptions of species is unfortunate but not to be criticized, since production of the first flora of a state is a task so great that it might have been impossible to accomplish if descriptions had been a part of it. A strong compensating factor is the thoroughness, fullness, and reliability of the keys, which are in excellent contrast to those of most of the descriptionless floras of the past. Concise statements of carefully selected characters of the genera contribute to the value of the work.

The interpretation of species cannot be classified as either "liberal" or strongly "conservative" (in the botanical vernacular), although it tends somewhat toward the latter. The unusually unimportant rank assigned to varieties in the makeup of the book will be disappointing to some but probably pleasing to others.—LYMAN BENSON, Department of Botany, Agricultural Experiment Station, University of Arizona, Tucson.

INDEX TO VOLUME VI

For classified articles see: Notices of Publication; Reviews. New scientific names are printed in bold-face type.

ERRATA

Page 233, line 33: for *sessillifolia* read *sessilifolia.*
Page 129, line 26: for *montanum* read *montana.*